AUG 15 1946

MACHINE DESIGN

August 1946

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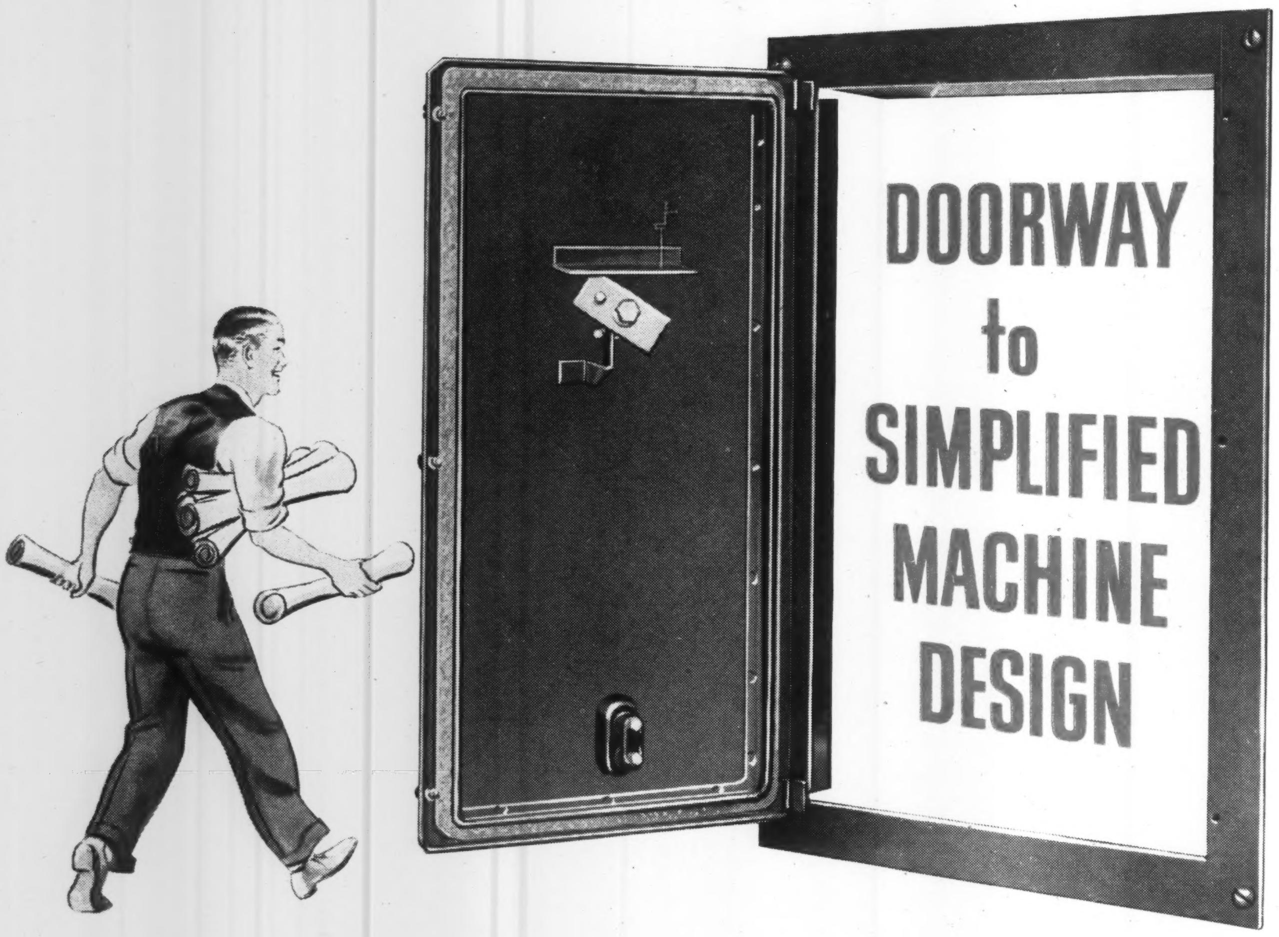
Silicone Insulation

Contour Forming



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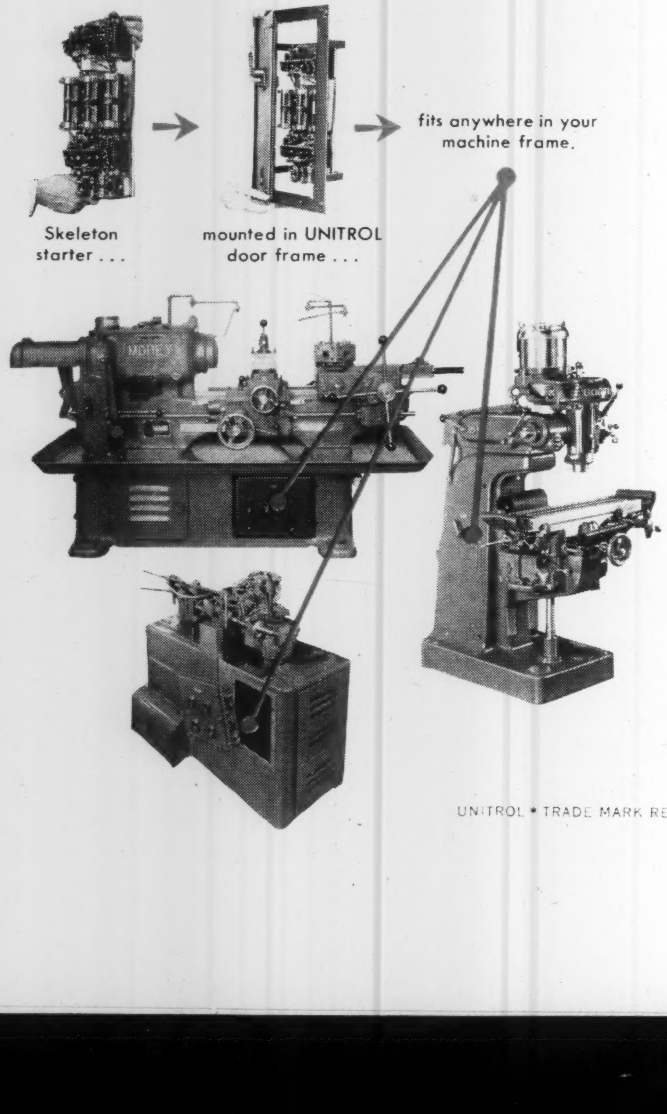
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THIS MONTH'S COVER: Precision mechanisms utilized in computer for Naval fire control which involves intricate computations, and their transmission for immediate positioning of guns. Designed by Ford Instrument Co., an affiliate of the Sperry Corp., the unit involves differential gear units, variable-speed drives, intermittent drives, magnetic clutches, and servo motors made to extreme precision

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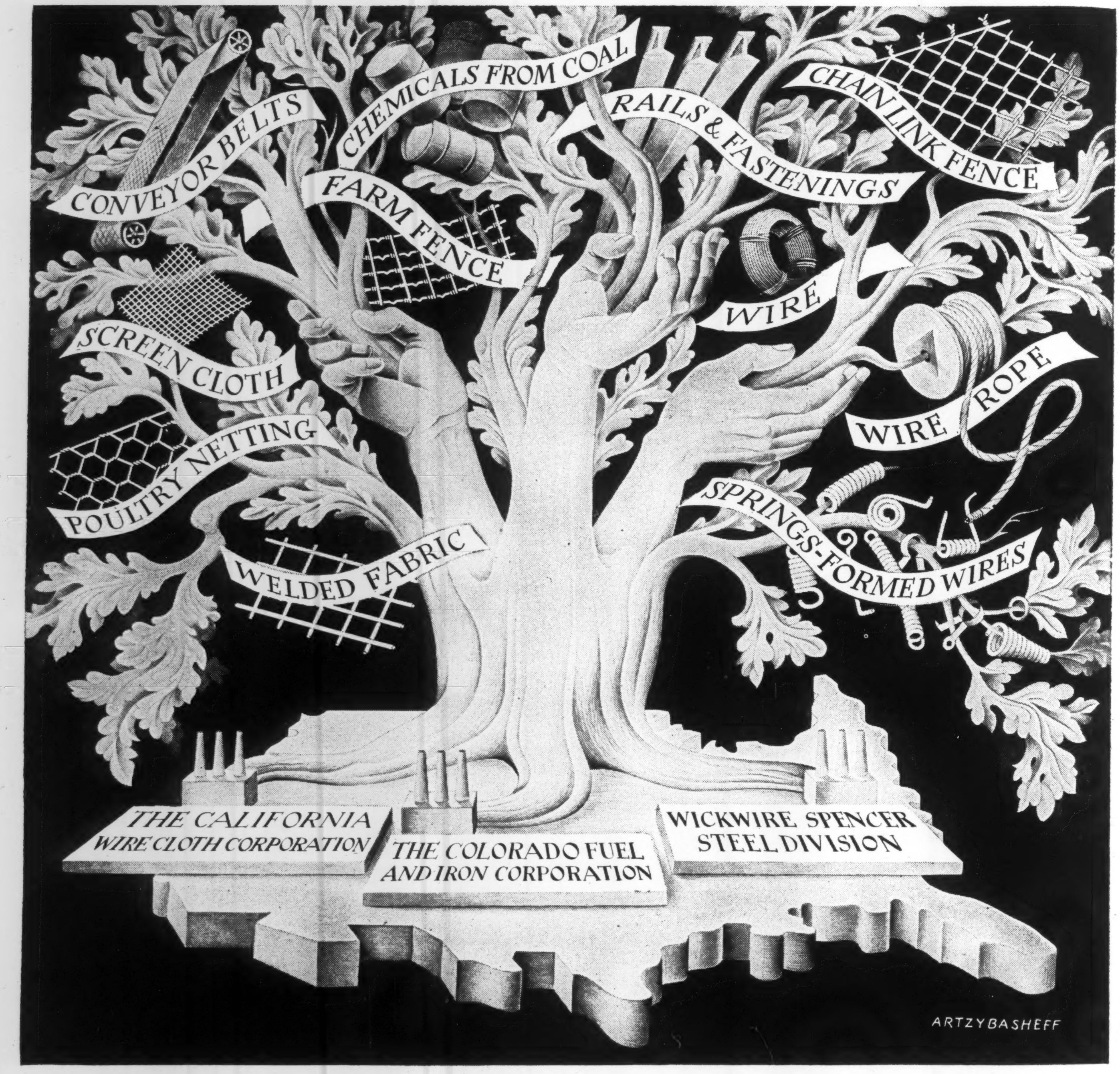
CONVEYOR BELTS
CHEMICALS FROM COAL
RAILS & FASTENINGS
CHAIN LINK FENCE
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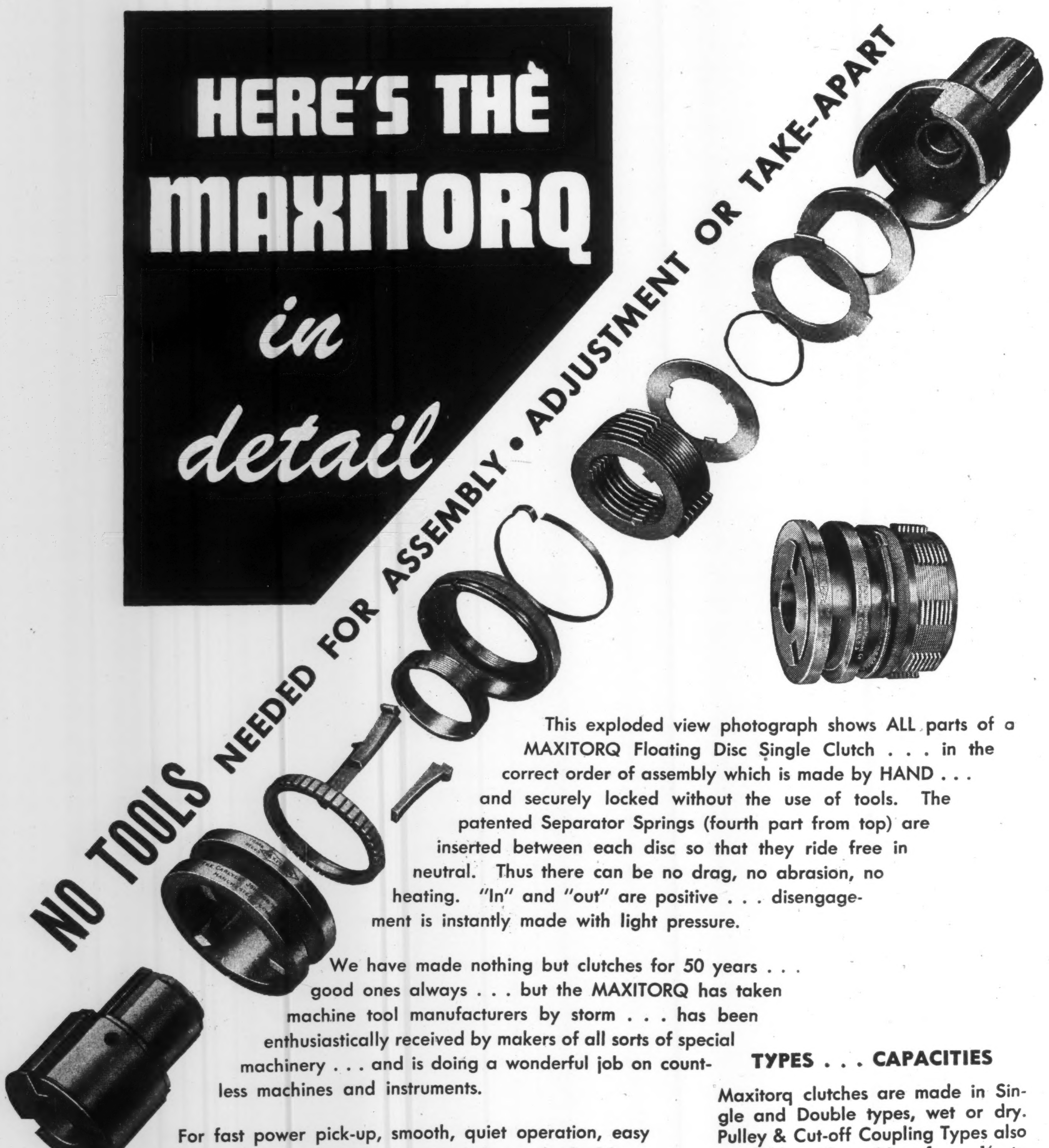

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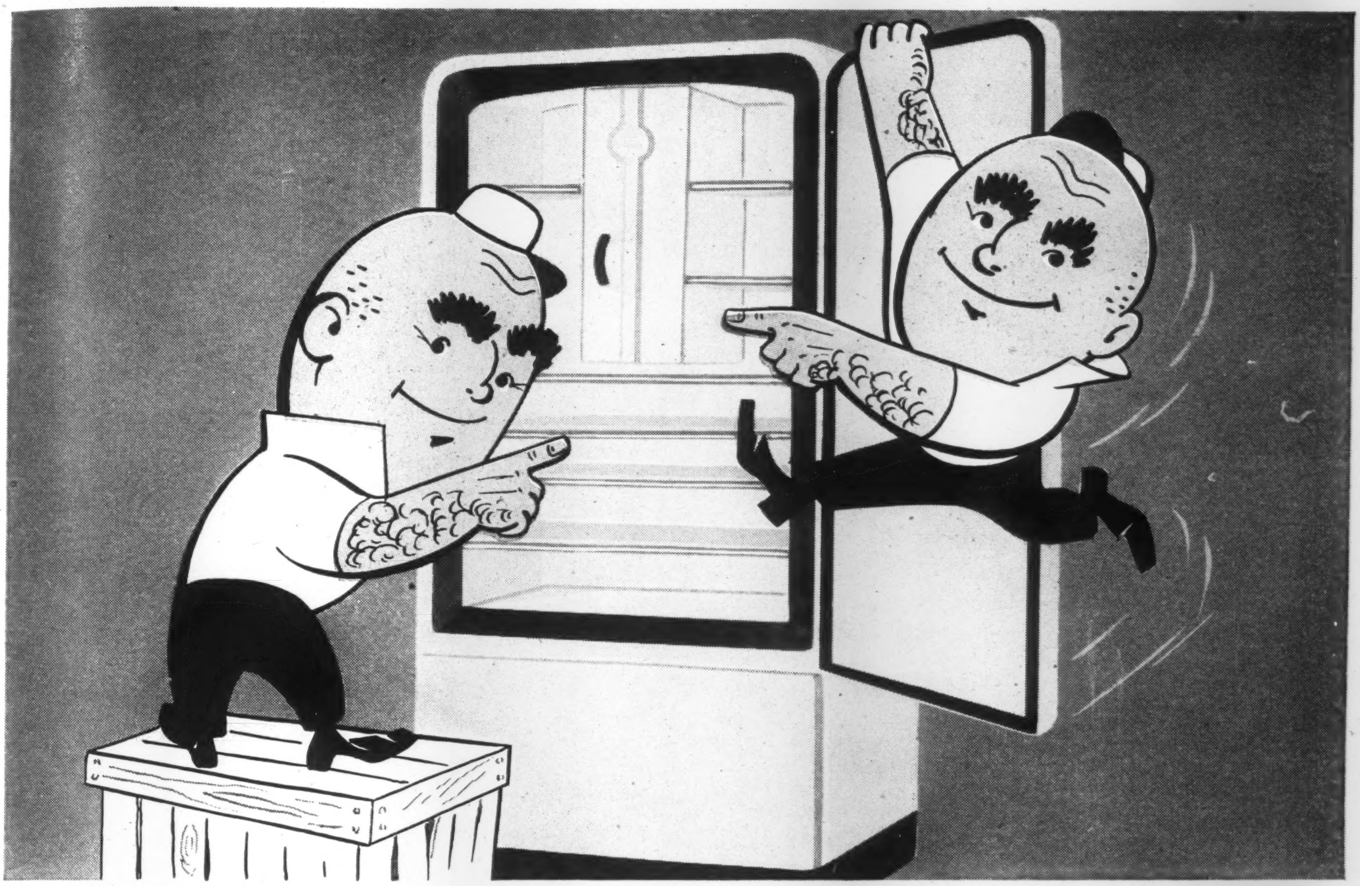

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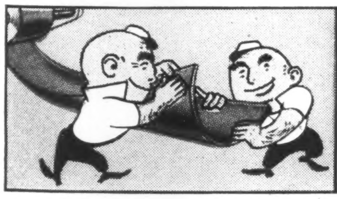

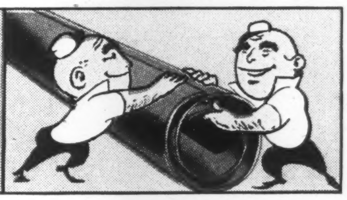

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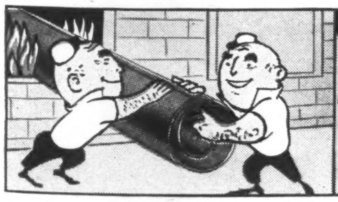
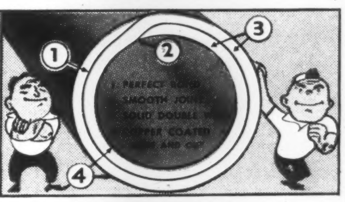
2 . . . into tubular form. Walls of uniform thickness and concentricity are assured by the use of close tolerance cold rolled strip. This double rolled strip passes through a furnace where the . . .





3 . . . copper coating fuses and alloys with the double steel walls. After brazing and cooling, it becomes a solid double wall steel tube, copper brazed throughout 360° of wall contact . . .

4 . . . copper coated inside and out, free from scale, closely held to dimensions. Hard or annealed in standard sizes up to 5/8" O.D. Special sizes cold drawn. Also in Monel, nickel and nickel alloys.

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Topics

ATMOSPHERIC CORROSION of lead coatings on steel is slowed down if the lead-coated steel is cold rolled. Cold reduction to an elongation of 1.5 to 2 per cent causes the coating to have fewer and smaller pinholes which are focal points for rust spots upon exposure.

MECHANICAL HOE for cotton or sugar beet crops is controlled by electric eyes which spot weeds and other undesirable growth to be exterminated.

INSPECTION OF MOTORS with prelubricated bearings which have been operating continuously 24 hours a day for over five years disclosed that none needed renewal of grease, according to a Westinghouse report.

CHINESE had no word for airplane in their language so they described it as "a ricksha in the heaven that goes without a coolie".

SIGNALS as short as ten millionths of a second must make an electronic register unit initiate corrective measures in order for a multicolor printing press to keep colors in register when operating at 1000 feet per minute. According to the General Electric Co. more than 75 per cent of multicolor work is accurately registered when using electronic control.

SHOT-PEENED shovels and other load-lifting tools produced by Union Fork & Hoe Co. last 2½ times longer than when not peened, under repeated bending at 90,000 psi. At 80,000 psi they last 5 times longer and at 70,000 psi they last indefinitely.

INTERRUPTING ENORMOUS CURRENTS at low voltage in storage-battery type of resistance welders seemed to be a difficult problem until carbon-pile rheostats were applied. According to the Progressive Welder Co., the use of this instrument has made storage-battery welding practical. Battery banks of 6, 8, 12, and 16 cells are connected to provide 4 to 10 volts and produce a welding current of 7000 amperes for each cell. Water cooling through lead tubing in the electrolyte prevents overheating the battery and excessive loss of electrolyte.

SILICONE INSULATION has made possible a 25 per cent reduction in the size of electric motors due to its higher thermal stability.

DRY GAS for hardening, brazing and sintering medium and high-carbon steels without carburization is produced automatically in a new endothermic atmosphere generator designed by Lindberg Engineering Co. After lighting the pilot, all phases of operation are pushbutton controlled. No charcoal is required, neither is periodic burning out to remove soot. Gas produced is carbon monoxide, hydrogen, methane and nitrogen in the proportions of 21, 40, 1, and 38 per cent, respectively.

ELECTRICALLY HEATED, a razor now in production is designed to heal abrasions and soothe the skin during shaving.

WATER PRESSURE to strip bark from trees at the rate of a half-million board feet per day is utilized in a new machine developed by Worthington Pump and Machinery Corp. The logs pass through a ring of 36 jets which shoot water at pressures of 1200 to 1400 psi and velocities of over 400 fps. This strips the logs at an average speed of 180 fpm, leaving them clean and smooth.

POWERING the Army's P-80 and delivering 4200 pounds of thrust, the I-40 jet engine delivers 80 times as much power as did the engine on Curtiss' Albany Flyer. This jet engine recently drove a P-80 nonstop 2470 miles across the United States at an average speed of 584.6 miles an hour.

MACHINE DESIGN

Partners in Science

By L. W. Chubb
Director
Westinghouse Research Laboratories
East Pittsburgh, Pa.

OUR present-day, highly complex, material civilization has been derived predominantly from the fundamental research and engineering of the past. In the past, development in the "Machine Age" depended upon the application of scientific knowledge collected for years by scientists and applied by a few geniuses such as George Westinghouse. Today, this slow method of technological development

Typical of American engineering achievement is this 400-pound portable radar unit. Silhouetted against the sky, the rotating "beach umbrella" antenna sends out short-wave radio pulses and receives wave echoes within an effective range of 80 miles will no longer suffice. Watt and his teakettle are replaced by men highly trained in thermodynamics and superacoustic gas flow. Goodyear and his kitchen stove are succeeded by men with knowledge of statistical mechanics of long-chain polymers, working in laboratories equipped with the most precise instruments and facilities. Scientific knowledge is urgently needed in ever increasing quantities and its application by industry must be more promptly attained to meet the demands of our modern civilization.

CO-OPERATIVE WORK of research scientists, engineers and inventors which has been responsible for our outstanding achievements in engineering developments was discussed by Dr. Chubb at the recent Westinghouse Centennial Forum. This article, based upon the author's talk, appeals for discovery of talent, proper training in basic fundamentals, and recognition of individual achievements

The more rapid unfolding of the secrets of nature, the encouragement given to scientific pursuits and especially the technical accomplishments during the late war have all shown more than ever before the great influence of science on our national welfare. This influence may be for good or for evil, depending upon our sufficiency of wisdom to control our affairs.

Assuming that controls will be found to protect against the potential dangers from the misuse of science, we must continue to accelerate our scientific activity to further improve living conditions and the ability of the public to satisfy its wants. Suitable incentives, effective stimulation and successful educational methods must be found to locate and develop the various talented workers who will be able to carry on effectively in the future.

Science and technology make up a loose type of partnership in which the partners divide the work, supplementing one another and, in addition to material success, receive a satisfaction in individual accomplishment. The whole structure for getting scientific information and subsequently applying it to useful products and processes is quite complicated. It includes the scientific workers followed up by our great industrial system based on private enterprise. The most outstanding of the partners in science responsible for initiation of new developments, are the research scientists, inventors, and engineers. They all play an essential part in any technological advance

Scientists are the producers of the raw material—new knowledge—which is subsequently applied in our industrial pursuits. Included in this group of scientists are the fundamental workers predominantly located in the universities, who are continually searching for new knowledge by theoretical and experimental methods. These pioneers are stimulated principally by the desire for new knowledge, having in mind no immediate technological application of the fruits of their work. Sometimes members of this group may deplore any consideration of any practical application, except possibly as a step to pry further into the secrets beyond the existing frontier. The scientific group includes also those more practical prospectors, usually classed as industrial research workers, located in industry and research foundations, who use the same scientific methods to obtain needed information for the solution of specific problems at hand.

In general, good scientists are well trained, inquisitive and resourceful in methods of seeking the truth. Their part in the scientific partnership need not always be directly or immediately co-operative. Their products—new knowledge stored in technical literature—are drawn upon by others for useful technological application or as a step for further scientific progress. Scientific discoveries and quantitative data obtained by them may be promptly useful or not used for many years. Eventually, however, practically all results find application and often multiple uses in the production of new products, processes, and services.

The next partner is the inventor. He devises something new and useful, employing existing knowledge. He is naturally an imaginative individual and asks himself, "How can this scientific knowledge be used, or how can I accomplish a certain function with the information available?" By "inventor" I do not necessarily mean one who always makes patentable inventions but one who suggests uses, combinations and applications of the abstract knowledge passed on by the scientists. Let us exclude the "nut inventor" from consideration, he being the one who suggests things without regard to their being better, practical or operative. True inventiveness is an essential characteristic in our scheme of technological progress and is found in a greatly varying degree in technical workers.

Greatest Burden Carried by Engineers

Then comes the third group of partners, the engineers, whose duties, talents, and inclinations lie in the development and design of new products and processes so as to accomplish a desired result in the most economical and efficient manner. Again, they usually use information which is at hand, and must co-operate closely with others so that their designs will be suitable for tooling, contain the proper materials, and meet public acceptance and existing competition. The work of the engineer is mainly development and design and, although it is not generally appreciated, the greatest burden and responsibility in industrial advances are carried by them.

Getting and applying scientific knowledge is not as clear-cut as this brief outline would indicate. The research scientist, the inventor and the development and design engineer are not necessarily separate individuals. The same worker may be a scientist and an inventor. Often the inventor may carry through with his own developments and design. Infrequently, all functions may be performed by the same worker. However, experience seems to indicate that at least some specialization is usual and desirable for the best results in any individual.

Today, in the esteem and appreciation of the public, science is in the saddle. The war has been called "a scientists' war" because so many weapons and defense systems were developed by scientists and used to meet the needs of the new mobile type of warfare. It is not generally realized that science applied by our chief enemy determined the blitz tactics, and we, unprepared, had to fight science with science.

Science alone could not have supplied our gallant boys with the weapons to bring victory. It was teamwork involving all partners, backed by the wonderful production facilities of the nation. Germany had good scientists, inventors and engineers but lacked the organization and industrial resourcefulness to compete with our system of private enterprise when things began to get tough and the handicap of preparedness had vanished.

Popular opinion has put science in the saddle for several reasons. In the first place, each group of partners in science likes to think that its contribution is the most important. The scientists and scientific journals were not at all backward in reporting their accomplishments. Then, popular reporting of scientific work is more newsy than the more prosaic work done by engineers. Finally, the most glamorous accomplishments such as radar, the atomic bomb and the proximity fuse are applications of scientific knowledge more recently acquired, and they are credited mostly to the scientists, particularly physicists and chemists who in special groups actually carried on the development. Probably well over 95 per cent of the activity on these glamorous items consisted of engineering and production. All of them were applications of prewar scientific knowledge. Although a great amount of specific research had to be done, most of the work of the scientists was invention and engineering development, and these are activities quite outside of their usual field.

There is a general feeling that, during the war, a great amount of fundamental scientific work was done and that the store of basic knowledge is full to overflowing. This, unfortunately, is not the case as the workers in pure science were taken from their usual pioneering activities and used to solve pressing war problems in industrial research, invention and engineering development. It is true, however, that the great amount of work done on specific problems resulted in new materials and quantitatitve and basic data, capable of extensive new application.

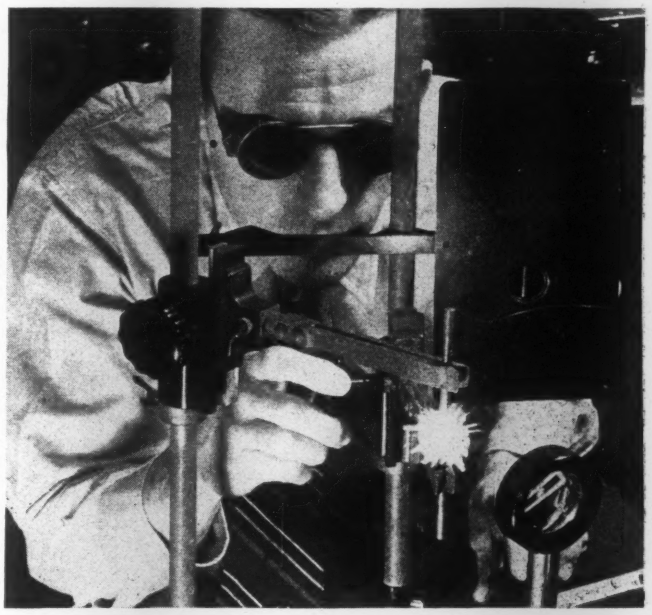
Now we need to revert to the usual sequence of technological development proved by past experience and to have the research scientists and professors back in the universities to do their chosen work in fundamental research and in training men to carry on in industry. This will help overcome the present shortage of technical workers for important postwar activities. Present college enrollment is enormous due mostly to the G. I. Bill of Rights. As a result, many technical workers will be graduated in the next three or four years but we fear that this will result in more quantity than quality. In spite of the possible further delay in supply of good men to industry, the most promising students now in college should be located and made candidates for postgraduate study.

Need To Encourage Scientific Work

The present shortage of technical workers is, we hope, only temporary. We should endeavor to meet the requirements for the future by instituting some scheme of locating individuals with an aptitude for scientific or engineering careers. We should then see that they have an opportunity to take the schooling and should encourage their following scientific pursuits by offering good remuneration and acknowledging their professional status.

The Science Talent Search of Westinghouse and Science Service is a wonderful beginning along this line. It enlists the help of teachers in high schools, it works with the science clubs and brings forth many promising embryo scientists. However, something more has to be done than evaluate scientific ability, knowledge and enthusiasm at high school age. A youth may belong to a science club because his best friend does, or he or she may see a certain amount of glamor in science subjects. Children are fickle at high school age and means should be found to determine whether their interest in science will be permanent. It seems as though too much importance has been given to the youth's desires at this flighty age and not enough to expert analysis of his natural bent which he discloses as a youngster in his play and boyhood activities.

B. G. Lamme, our chief engineer for many years, took great interest in the many college graduates who had come to Westinghouse on the training course. He would seek an opportunity to call each young man in for a heart-to-heart talk. He did not ask the student's liking or ambitions at the time but would talk about almost everything except his future career. The object of this informal, friendly talk was to swap stories of boyhood pranks and what was of interest in work, play, sports, etc. Such talks allowed Mr. Lamme to catalog the men. He could classify them accurately as being good in design, development, testing, production management, application, or research. Repeatedly, he found graduate engineers whom he predicted would not be successful in any branch of engineering.


Wave-length portraits of metals are made in this instrument to identify chemical composition. Spectographically pure iron is being recorded by passing an electric arc between the two specimens

As long as a youth is allowed to pick his course of study based on desires of the moment, is influenced by his parents or is attracted by the lure of profitable work, the colleges will continue to be wasting effort on a great many misfits. Frequently students in upper classes, and even graduates from technical schools, do not know what their chosen career is all about.

It seems that some scheme of classification and selection such as Mr. Lamme used so successfully for predicting the best specialization for graduate engineers would be helpful in selecting the proper college course before training is started. Qualified anlysts, I believe, could work up some formulae or interview system which could be used to advantage in orienting prospective college students. Questions and study of biographies, I think, clearly show that the natural bents in childhood indicate permanent interests.

For the last few years much has been written and said regarding changes in engineering curricula. Some of the engineering colleges have changed to a five year course or are contemplating such a step. The main object of this is to have more opportunity to include the humanities in the curriculum. This change has its advantages. Graduate engineers have, as a rule, been deficient in social, economic and cultural training because of the lack of interest and the intensive schedule of techical subjects which they have to carry. We in industry see the advantages of the change in curricula but feel that the additional 25 per cent of the engineering course should be partly used to give more training in fundamental studies.

The unusual success of scientists, especially physicists, who worked really as engineers on war problems is significant. There is no doubt that their accomplishments were outstanding in the radiation laboratory at M.I.T. and the various centers of activity on the atomic bomb project. Their great success as inventors and development engineers was the result of their good training in the fundamentals of science. They definitely could do the engineers' development work better than engineers could have done the scientific research required for the various tasks. Physicists, as individuals, are probably no brighter than engineers on the average but their type of training is characteristically different. Physicists and chemists in their more advanced course are taught fundamentals, while the corresponding mechanical, electrical, and chemical engineers depend too much on practical training, empirical formulae, and handbook data, to be really resourceful in invention and development of new things.

Apparatus using light beams to measure the lengthening of metals under test. The galvanometer, directly opposite the observer, receives minute impulses from photoelectric tubes to record the increase in length

Engineering today includes many branches such as electrical, mechanical, electronics, aeronautical, chemical, hydraulic, lighting, acoustic, sanitary, and others. Also, nuclear engineering is just starting. These all involve the application of the various subdivisions of the physical sciences. One who knows and uses the basic scientific knowledge rather than empirical data can be useful in any branch of engineering development. The physicist keeps in mind the fundamental mechanism of engineering phenomena. The engineer has a tendency to work empirically with gases, for instance, considering them as elastic media, or an electrical current or a heat flow problem as a fluid flow phenomenon rather than working with the proper physical conception of the mechanism involved.

Knowledge of Fundamentals Is Necessary

Empirical data and engineering short-cuts do not exist for new applications of science in engineering development. They are built by the toil of design engineers who, depending upon experience, transform the products of development engineers into the most practical and economical form for manufacture and use. A more complete training in fundamentals in the college course will surely be beneficial to the design engineers as well, for their great worth and proficiency are acquired as a result of experience after graduation.

American inventiveness, stimulated by the incentives of a successful and proved patent system, is responsible for much of the better living and working conditions, for better products at lower cost and for millions of jobs resulting from the production, distribution and sale of patented goods. Although American inventiveness now stands out ahead of that in other countries, efforts are being made by a national committee and contests are being contemplated by the Navy to see what more can be done to develop inventiveness in individuals.

The inventor, with his natural intuition for sensing possibilities of using and combining scientific knowledge to create new scientific devices, materials and processes, must also depend upon basic scientific knowledge as his tools.

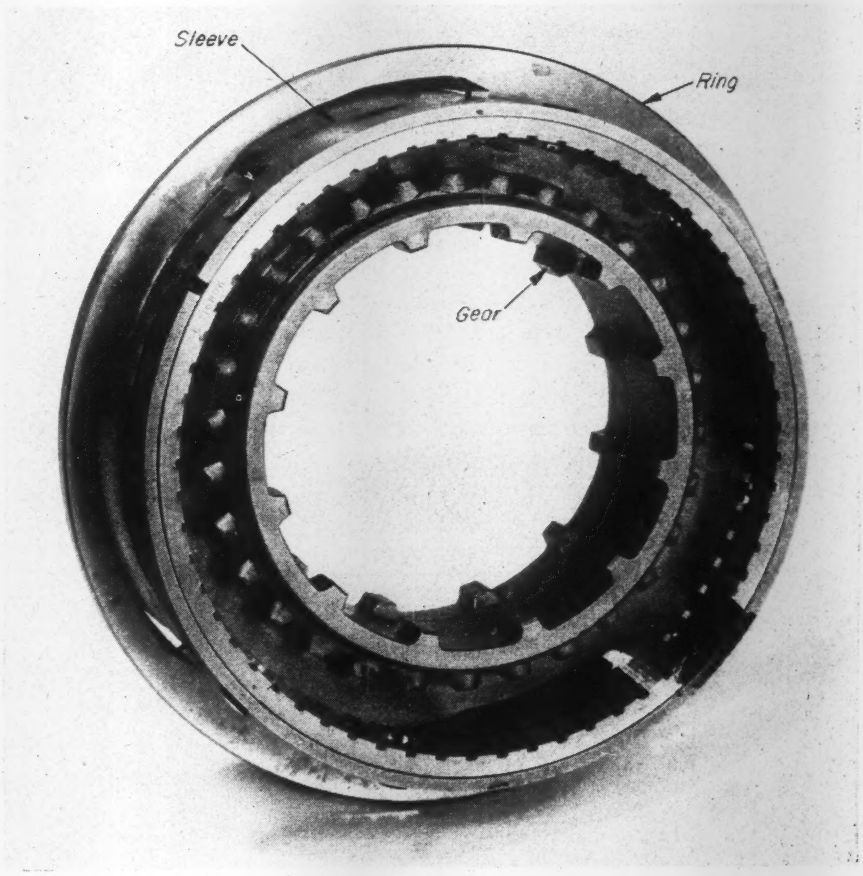
While we are considering incentives and rewards for accomplishments, we should not forget the scientist and work out something to reward him for outstanding discoveries and valuable contributions which cannot be covered by patents. They are the things from which industrial advances stem. Attempts in the past have not met with success, but some method based on usefulness, degree of application of discoveries, although delayed in time, might be worked out.

Many may feel that the type of training for those engineers who enter other fields than research, invention and development of new products should have even more practical education in their college course. The practical knowledge needed in such other engineering comes with experience after graduation. Our observations indicate that specialization should begin after graduation. Workers in research, invention and new application of science should continue to keep up on scientific information. Designers, industrial engineers and others should continue their education by following progress in their chosen field of specialization.

During this postwar era, there are new horizons in science and possibilities for much more rapid progress in its application. Everything possible should be done to meet the challenge and help each group of partners do its essential and supplemental part.

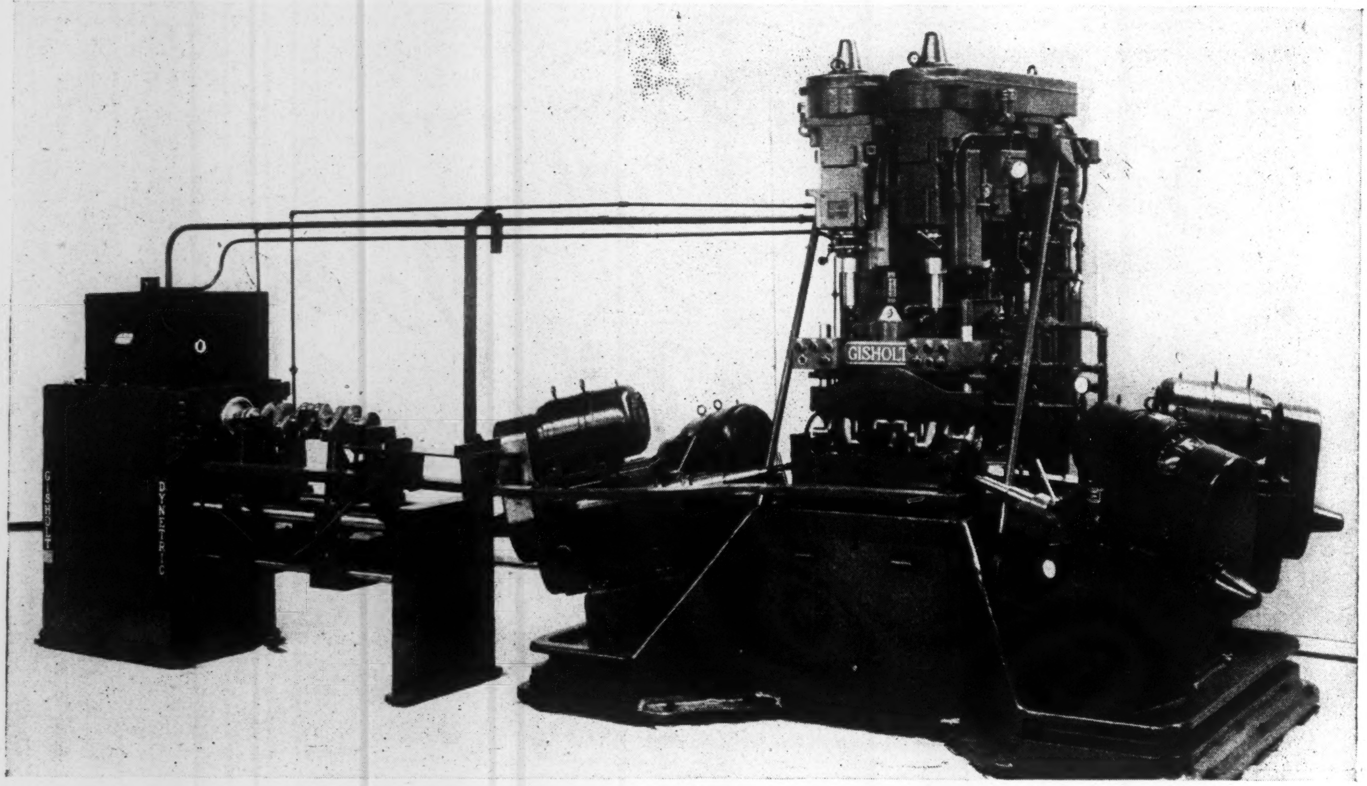
Scanning THE FIELD for Ideas

HYDROGEN brazed into one piece during the carburizing process the clutch gear and ring shown illustrate economies obtainable by combining two operations into one process and the possibilities of employing both brazing and welding in highly stressed assemblies. Designed by the Spicer Manufacturing Corp. for use in the synchronizer assembly for heavy-duty truck transmissions, the clutch gear is a machined forging and the ring is rolled and welded. Four drive screws locate the two parts during the brazing operation. Synchronizer sleeve used in the assembly is from 1035 to 1040 strip stock, blanked and rolled into a cylinder. A final shaving operation is performed on its cam slots after rolling. This provides for correct spacing and alignment of the synchronizer blocking cam surfaces. A tongue and groove at the split opening on the sleeve assures alignment during the shaving operation and subsequent assembly. The cam surfaces are induction hardened.



Dynamic balancing of automotive crankshafts may be accomplished in an average time of 60 seconds and within an overall accuracy of 0.2 ounce-inch through the development of a semiautomatic measuring and correcting machine. Consisting of two electrically interconnected units developed by Gisholt Machine Co., the equipment measures the unbalance of the workpiece. From these indications, six drill heads are set automatically to perform the corrective operation.

Controls for balancing consist of a pair of selector switches and six weighing dials numbered to correspond to the correction points on the crankshaft. These selector switches and dials are turned in sequence to cause a meter on the machine to read zero. Balance indications from the dials are transferred to the corresponding drilling heads by self-synchronous transmitters and receivers. Each receiver carries a cam by means of which the ounce-inch units of the balancing unit are converted into inches of depth of drilled hole. When a

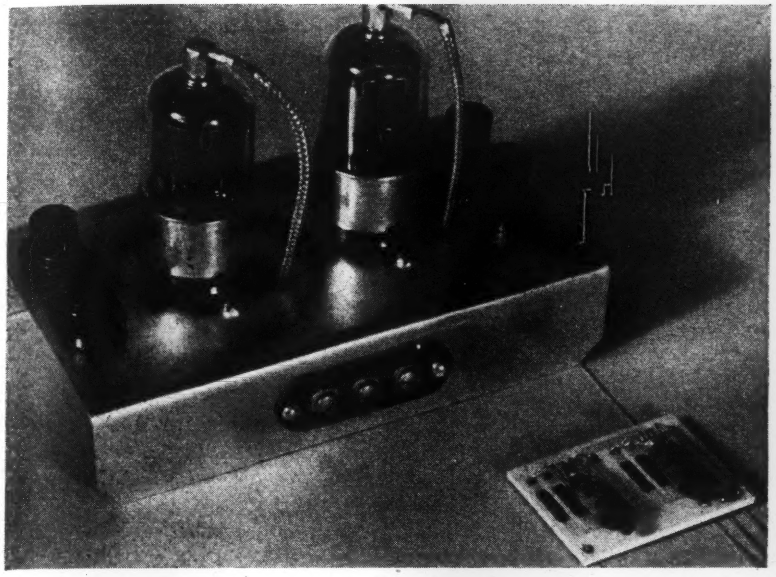


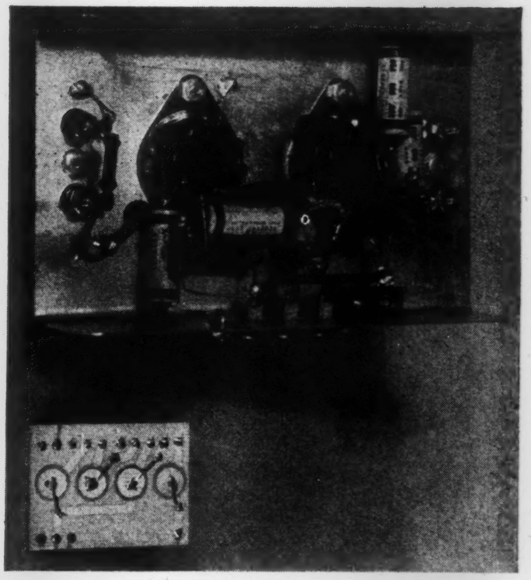
crankshaft is transferred from the balancing unit to the drilling unit, the drilling heads are set automatically to remove sufficient metal from six positions to effect the balance indicated. After the traverse motion of the drills is initiated by the operator, a depth gage contacts the cam on the receiver to get the depth measurement required for the drilled hole. One drill will repeatedly produce holes to the same depth, for the same receiver setting, to an accuracy of 0.003-inch. This represents an error of less than 0.05 ounce-inch for 1$\frac{1}{8}$-inch diameter drills.

Control circuit between the two units of the machine, shown above, is so arranged so that the receiver information is transmitted to its drill spindle within three seconds after the drilling cycle is started. This makes possible the obtaining of balance indications on another shaft while corrections are being performed. A green light on the balancing unit informs the operator when the drilling unit has picked up the information concerning the previously measured shaft.

On the control panel for the drilling unit is a red light for each drill head. When any drill becomes dull the light associated with that spindle is turned on by a hydraulic pressure switch.

Printed circuits shown at left, obviate conventional "custom" wired components for electronic units and reduce radio sets, hearing aids and other electronic units to an unbelievably small size. The new technique, developed for use in the proximity fuze by the National Bureau of Standards in collaboration with the Centralab Division of Globe Union Inc., involves the use of a thin ceramic base upon which is printed the necessary cir-





cuit wiring and resistors. To this printed wiring are soldered the required paper-thin capacitors as well as subminiature tubes, external leads and other components.

Eliminating the tedious and time-consuming hand soldering along with the ever-present possibility of errors, these printed circuits make possible the production of stable units in miniature size capable of withstanding a force of 10,000g. To illustrate graphically how this development has materially reduced the space required for a radio circuit, the photographs above show top and bottom views of an actual two-stage amplifier produced both by this new method and conventional radio assembly.

Ceramic plate or chassis material is steatite, a nonabsorbent "sapphire-hard" plate produced by pressing and firing a compound of talcs and clays. Printed wiring is silver, applied by silk-screen lithography in the form of a paste of finely divided silver particles in combination with binders and solvents. Heating in a furnace burns off the solvents and binders, leaving the silver wiring adhering to the ceramic with a tensile strength of approximately 3000 psi.

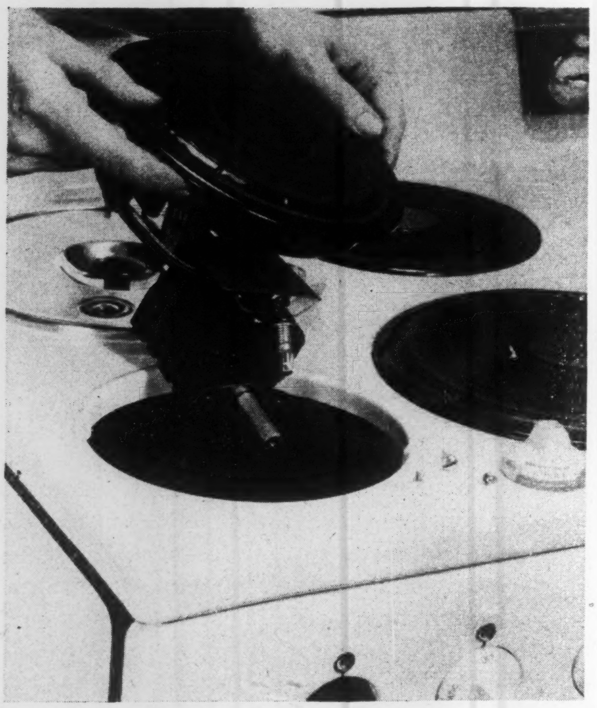
Resistors are produced by spraying or screening a heavy paint consisting of a conducting material such as finely divided carbon, a filler or inert material, a solvent, and a binder onto the steatite through accurately positioned masks. Resistors may be produced accurately within the range of 3 ohms to 200 megohms by varying the length, width, and formulation of the paint. To stabilize the resistors they are placed in an oven for several hours and are then coated with a special resin to protect against effects of humidity.

Capacitors are small paper-thin disks of titanium dioxide ceramic, silvered on each side. They have been produced to range in value from 6.5 to 2000 micromicrofarads. Soldering capacitors to the printed circuits requires a low-temperature bismuth solder. Silver solder containing at least 2 per cent silver is used for fastening leads of tubes, etc.

In addition to each circuit being a duplicate, it is an easy matter to trace a circuit because of its open-style construction. In exhaustive tests these new units have been found to be extremely stable, quiet and in many cases superior in performance to those using standard components.

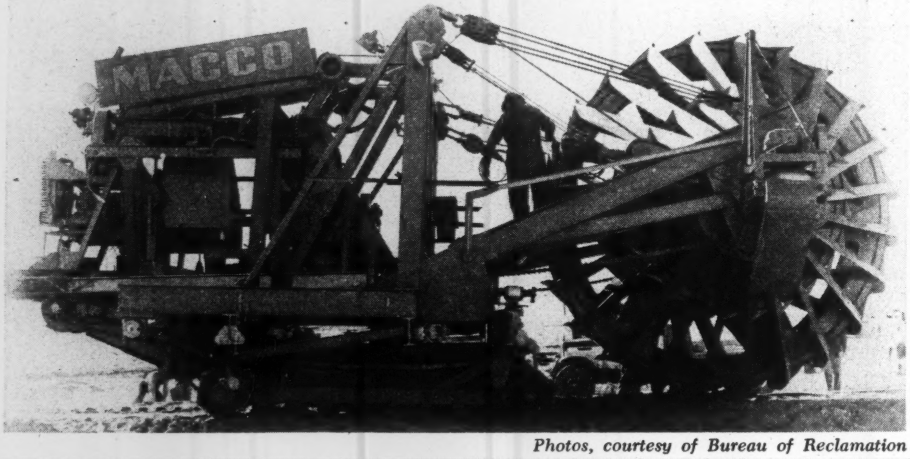
Protection against collision is a new outgrowth of peacetime applications for radar. The receiver-indicator unit shown below will be used to safeguard the City

of Richmond, a Baltimore-Norfolk night boat on the Old Bay Line. It will provide protection in darkness, fog and other bad weather conditions for distances between 100 yards and 32 miles. The equipment, designed by Westinghouse Electric Corp., is of the continuous-plan-position-indicator type, providing a continuous picture of ship traffic and shoreline conditions throughout its range. Mounted convenient to the watch officer's station on the bridge, the cabinet has a 7-inch cathode-ray tube in the top panel to show the radar picture.

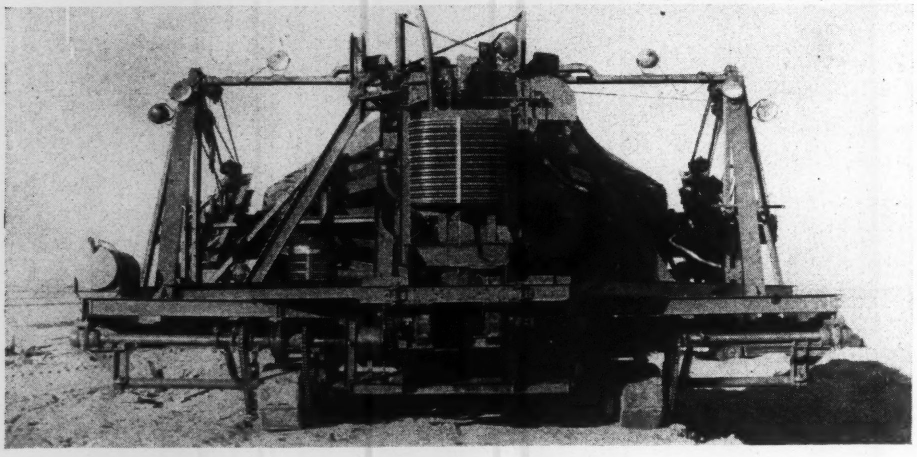


Red heat within 40 seconds for domestic electric range surface units is obtainable with the heating coil shown being installed in the range at left. Utilizing a supercharger switch arrangement the unit becomes over-energized to four times its normal wattage from 1200 to 4800. When temperature has been reached the switch automatically provides for a return to the temperature selected on the control dial. The supercharger switch used in the control circuit designed by the Proctor Electric Co. is of simple design since it is merely used as an "on-off" and as a supercharger when speed in heating is desired. When quick heat is required, the switch temporarily disconnects other units in the range during the superheating cycle so that the wattage capacity of the range will not be exceeded. A delay flash is also included so that if another supercharger is heating a unit, heating is delayed so that only one supercharger is in operation.

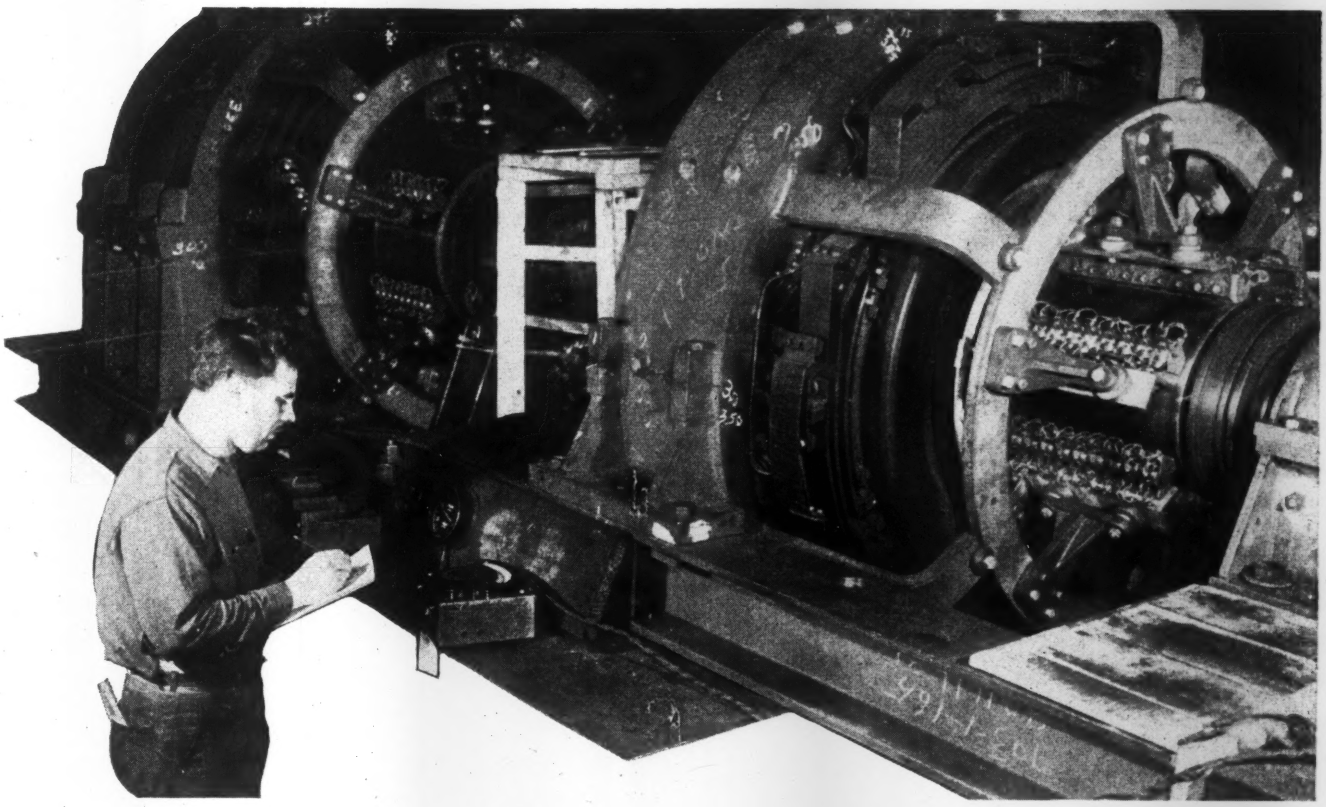
Included in the supercharger circuit is a thermostat so that the temperature of the unit will not be exceeded even though the heating elements may be warm at the time the current is applied. In contact with the utensil a thermostat maintains constant the temperature for which the unit is set. This feature precludes the possibility of burning food.



Photos, courtesy of Bureau of Reclamation



Adjustable axle lengths on the canal digging machine illustrated at left provide for setting the tracks upon which the machine moves, straddling any size ditch within the limits of the digger. To obviate leveling the ground over which the machine operates the cutting wheel setting may be varied by means of cables. Designed by the Macco Construction Co. the machine has a device to keep the conveyor level no matter how deep the ditch being cut may be. Conveyor which carries off the dirt in this machine is internally suspended within the cutting wheel by means of rollers.



Silicone Insulation

. . . for electrical machinery withstands high temperatures, moisture and many chemical reagents

By C. E. Kilbourne

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MANY questions have been raised concerning the insulating characteristics of silicones and the practical advantages they offer when applied to electrical machines such as the motors in *Fig.* 1. While present-day knowledge of these comparative newcomers in the field of insulating materials cannot answer all such questions, it can answer some of them and point the way toward probable fields of application for the future.

What is silicone? Silicone is the generic name of a large family of semiorganic compounds which lie between the organic family of the hydrocarbons and completely inorganic materials. The body of the molecule of organic hydrocarbon materials is built around chains of carbon atoms which form carbon-to-carbon networks with other elements. Silicone compounds are similar to these hydrocarbons in their general type of chemical structure except that, in place of the carbon atoms, silicon oxide radicals constitute the chains to which the other elements are attached. The greater thermal stability and chemical inertness of the silicon oxide backbone, as compared to the carbon backbone, imparts to silicone materials their most advantageous properties.

Silicones under normal conditions exist in several states. Some are solids, others liquids, and a few are gases. The

Fig. 1—Above—Testing motors insulated with silicone materials. These insulations withstand temperatures up to 175 C without deterioration

ones of particular interest as insulating materials exist as resins, similar in appearance to the organic resins which have been used for machine insulation for years. With proper solvents they become varnishes for treating glass cloth or tape, asbestos paper or cloth, and for dipping and impregnating coils. Some serve as stickers for pasting together mica flakes, *Fig.* 2, and as binders in assembled insulating systems.

THERMAL STABILITY: The most frequently thought of advantage of silicones, contrasted with commonly-used organic materials, is the thermal stability of the silicone compounds. Organic compounds, when used with inorganic materials such as glass, asbestos, and mica, are stable for long periods of time at temperatures up to 125 C. Above this temperature they deteriorate rapidly. Silicone compounds, however, when used in the same manner, have shown comparable stability up to 175 C and probably can be used with somewhat reduced length of life at even higher temperatures. *Fig.* 3 compares the heat resistant and dielectric properties of several silicone materials with one of the best available organic varnishes. In addition to long life at these temperature levels, some silicones possess a marked resistance to combustion at temperatures which will destroy them.

RESISTANCE TO WATER AND MOISTURE: Both silicone and organic materials are resistant to water absorption, but the silicones appear to have exceptional water resistant properties. Dri-Film, a coating for organic and ceramic materials, is a silicone-containing compound closely related to the silicones. Materials treated with it shed water easily. Samples of silicone insulation which have been immersed in water for long periods of time, when dried out, have withstood approximately the same voltages which they withstood before such treatment. Organic insulations often suffer a material decrease in break-down voltage after such treatment. Insulation resistance tests on organic-varnish and silicone-varnish impregnated coils immersed in water and periodically withdrawn and tested for insulation resistance show that the rate of decrease in resistance is much slower, about ¼ the rate, for silicone impregnated coils as for organic-varnish impregnated coils.

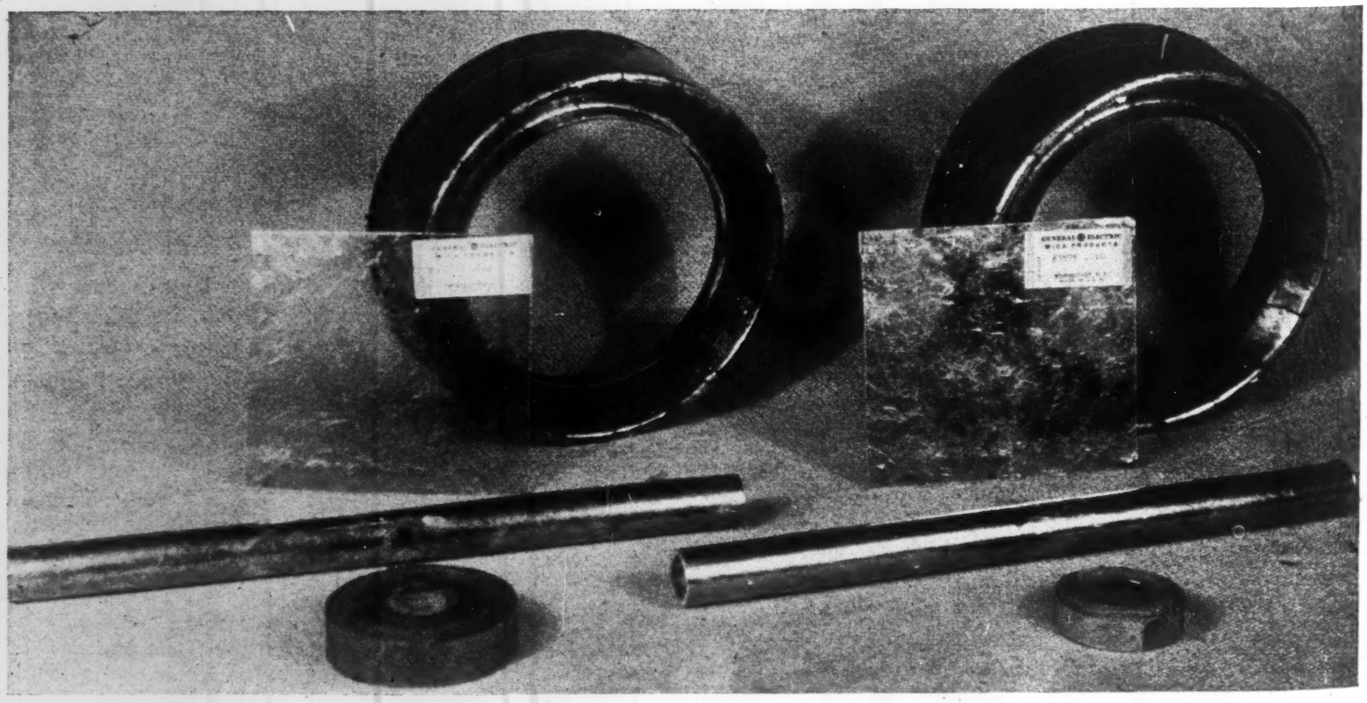
RESISTANCE TO CHEMICAL REAGENTS: In its resistance to various chemical reagents, silicone presents some surprises. Unlike organic varnishes, it is quite resistant to most alkalies. Silicone-treated glass cloth samples exposed to 10 per cent sodium hydroxide, and others exposed to concentrated ammonium hydroxide for 24 hours, were not visibly attacked. Probably other alkalies will give similar results. Several acids, including concentrated hydrochloric, nitric, acetic and dilute acetic acid did not attack samples. Sulphuric acid, however, did attack the samples and rapidly ruined them. All these chemicals severely attack organic varnishes. Action of hydrochloric and nitric acids on silicone resin *C* is shown in *Fig.* 4. Effects of various reagents on different silicone resins are shown in TABLE I.

Lubricating oils, transil oil, and carbon tetrachloride attack silicones more severely than they do organic materials. Their rate of attack, however, does not seem to be sufficiently rapid to cause great troubles.

DIELECTRIC STRENGTH AND POWER FACTOR: Silicone films possess dielectric strengths comparable to those exhibited by other insulating resins. They lie in the general range of 1000 to 2000 volts per mil depending upon the particular silicone resin chosen and upon the treatment given it. The power factor of silicone-insulated glass sheets is unusually low. TABLE II shows the power factors of several such sheet materials using different resins. As a comparison, the power factor of varnished cambric cloth at 100 C would lie in the range of 12 to 20 per cent and at 150 C it would be too high to measure.

MECHANICAL FRAGILITY AND BONDING STRENGTHS: The various mechanical properties of silicone resins are generally inferior to the corresponding properties of the best

Fig. 2—Silicone-mica components of machine insulation showing commutator cones and silicone-mica sheet tubing, and tape



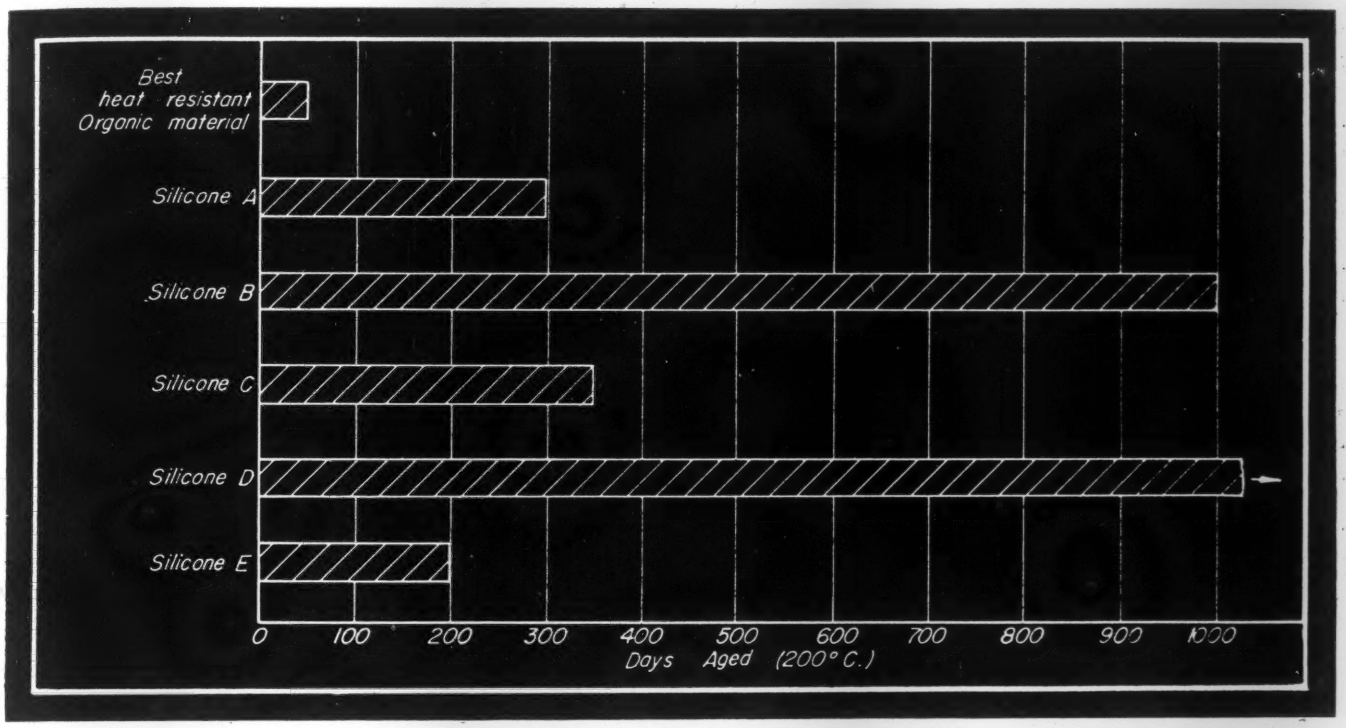


Fig. 3—Thermal resistance of silicone-treated Fiberglas as determined by dielectric breakdown

organic materials. Silicone films are more fragile, have less abrasion resistance and greater tendency to craze than do organic films. When used as bonding agents or stickers, they are not as strong as other commonly used materials. Recent improvements in silicone chemistry and in the technique of employing silicones has done much to minimize these objectionable properties and, with further progress and experience, these properties undoubtedly will become of minor importance.

TABLE I

Chemical and Solvent Resistance of Silicone Resins

Reagent	Resin A	Resin B	Resin C	Resin D	Resin E
HCl (Conc)	Not Attacked	Not Attacked	Not Attacked	Not Attacked	Not Attacked
HNO_3 (Conc)	Not Attacked	Darkens 2-6 Hrs	Not Attacked	Darkens 2-6 Hrs	Darkens 1-2 Hrs
H_2SO_4 (Conc)	Attacked	Attacked	Attacked	Attacked	Attacked
NaOH (10%)	Not Attacked	Not Attacked	Not Attacked	Not Attacked	Not Attacked
NH_4OH (Conc)	Not Attacked	Not Attacked	Not Attacked	Not Attacked	Not Attacked
CCl_4	Softens and Swells	Softens	Softens and Swells	Softens and Swells	Softens and Swells
Oil* (25°C)	Softens	Slightly Softens	Slightly Softens	Not Attacked	Softens
Oil* (100°C)	Softens	Slightly Softens	Slightly Softens	Slightly Softens	Softens

*No. 10 Transil.

The thermal endurance of insulation has long been recognized as an important limiting factor in machine design. In many cases this factor is the primary basis for establishing the rating of a given motor or generator frame. Not nearly as well recognized, however, is the fact that other limits in establishing the ratings of particular types of machines are not far removed from the thermal ratings. Removal of the thermal limit immediately forces consideration of other features.

Neverthless the advent of silicone resins is an important step in insulation development. When these resins are combined with inorganic materials such as mica, asbestos and glass fibers, new opportunities in the design of machines are opened. Designers can take advantage of the increased thermal life in several ways such as

1. To obtain increased life of machines
2. To permit operation in high ambient temperatures
3. To allow prolonged overloads
4. To reduce size and weight of machines
5. To make machines nearly fireproof.

When it is desired to maintain conventional size, weight and temperature, increased insulation life may be of particular value for important base-load machines where a premium is placed on continuity of operation.

Ability to operate in high ambient temperatures will be helpful when electrical machines are used with restricted ventilation or in boiler rooms or other places where the cooling air is unusually hot.

Present day machines may be required to carry 25 per cent, 50 per cent, and occasionally even greater overload for specified short times. The amount of overload and the time permitted depend upon the maximum temperature the insulation will stand and upon the rate of rise, that is, the thermal storage in the machine. Raising the maximum permissible temperature will not only increase the time possible for a given overload, but also will permit greater overloads as far as the insulation is concerned. This feature opens distinct possibilities for drives such as rolling mills, crushers, and wood chippers, and for the generators supplying these loads.

Reduction in size and weight of machines through increases in normal-load temperature is often the first thought of application. While this is attractive, and will be used extensively in machines where weight and size are at a premium, increases in losses and excitation and decreases in power factor and stability—one or more of which are apt to accompany a weight decrease—will call for careful evaluation of the application.

Two other considerations also enter the picture when reductions in weight and space at the expense of temperature are being evaluated. Some machines, if operated at normal load temperatures of 175 C, will have greatly reduced overload capacities because of the phenomena of temperature creep. This occurs when the temperature and copper losses are so balanced that an increase in temperature, which increases the copper losses, generates enough additional losses to again increase the temperature and so on until the machine destroys itself. This may happen in smaller machines more often than it does in larger ones.

Machines having end shield bearings, where the bearings are close to the hot areas, will have excessive bearing temperatures. Measures must be taken to reduce these temperatures or to provide lubricants that will operate satisfactorily in spite of them. In larger machines with pedestal type bearings this difficulty may not arise, but others of a mechanical nature may. These high-temperature machines will pass through greater variations in temperature than present machines do, and will therefore be more subject to temperature-stress fatigue.

In spite of these problems that have been and will be encountered, ways will be found to build lighter weight machines. Already, with some of the sacrifices that have been outlined above, silicone-insulated machines 20 to 35 per cent lighter in weight per power rating per rpm have been designed.

The high resistance to combustion that some silicone resins exhibit is a valuable characteristic. Such silicone insulated machines will not burn in the usual sense of the word. One machine failed to catch fire when molten metal ran out of the rotor and over the end windings. In others, when short circuits have occurred, there were no fires and little damage, if any, to the insulation except in the immediate vicinity of the short circuit. This should be of advantage in machinery, such as that used in transportation, marine, land, and air where fire is not only a hazard to the machinery but is of even greater danger to life. Silicone insulation may also be of importance in other applications and may affect insurance rates sufficiently to justify assigning a definite economic evaluation for silicone insulation on its fire resistance.

Withstands Exposure to Weather

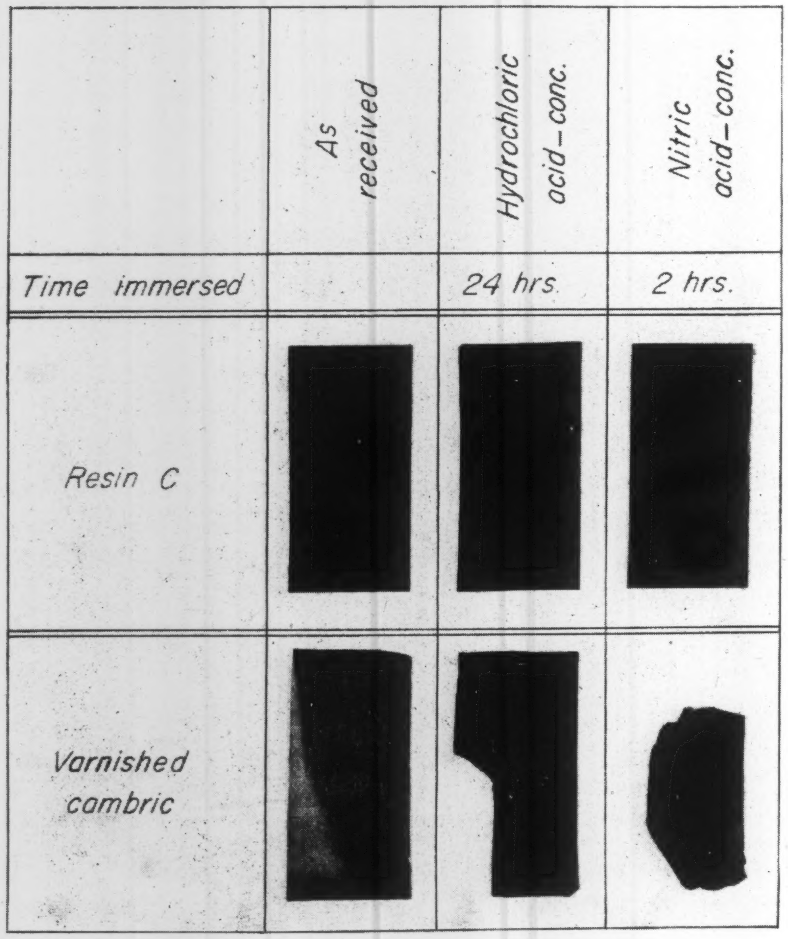
Moisture resistance of insulation is also a characteristic of importance. Organic-varnish insulated machines which stand idle for long periods of time without protection to prevent absorption of moisture frequently require a drying out period to put their windings in operating condition. Machines in unusually damp locations require special protection. Silicone insulation offers possibilities of standing more exposure than organic insulations do now. This may be of importance for dock and shipboard apparatus as a real contribution to reduction in maintenance. Windings with the new material will probably show superior resistance to salt moisture and salt spray and, while experience is not yet sufficient to recommend direct exposure to the elements, progress in that direction is possible and probable.

The chemical resistance of silicone will open numerous possibilities for improvements in machinery for the chemical industry. Already some silicone-wound motors in a plant having alkaline fumes have remained in operation several times as long as motors with conventional windings.

Undesirable characteristics of the material are of sufficiently minor importance that they will be overcome whenever the application is otherwise favorable. Mechanical fragility and difficulties in manufacturing techniques will be mastered in the chemical department and on the manufacturing floor. While these are temporary stops for some machines, they do not now prevent the use of the material in many places, and they will be less and less important as obstacles as further development proceeds.

During the last several years a number of silicone insulated machines—induction motors, synchronous motors and direct-current motors

Fig. 4—Chemical inertness of a silicone resin exposed to concentrated hydraulic and nitric acids contrasted to attack upon varnished cambric



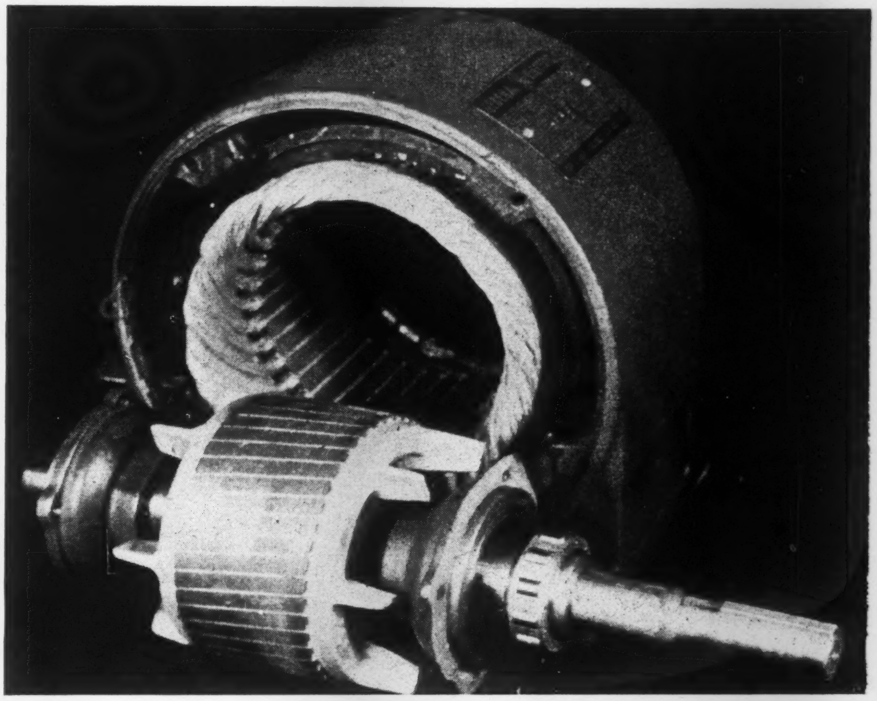


Fig. 5—Small silicone-insulated induction motor, showing insulation on stator windings

and generators—have been built. The pilot machines were a number of small induction motors whose armature windings were insulated with silicone, glass, and mica in various arrangements. The first of these ran only a few days at 250 C before a ground failure due to a mechanical weakness took place. After this fault had been remedied, more running caused a bearing failure, and the armature of the motor was subjected to 400 C for a long period of time without electrical damage to the insulation, but damage to other parts caused the machine to be discarded.

Three other motors, totally enclosed, nonventilated, were then built, each with slightly different insulation design. These motors, like the first one, were designed merely to get hot and to have no particular running characteristics. The motors were set up and run under load every day during working hours, and cooled to room temperature during the night. During the week-end, water was run into the endshield to just below the bottom of the lower slot and stood there until drained off on Monday morning. Megohmeter readings to ground were taken at the end of the week and at the beginning of the week, after humidification and before starting up. In every case after a week of running, the megger readings were infinity and, even after the humidification of the megohmeter, readings were generally high.

The second motor ran for ten weeks when it short-circuited between phases. Examination showed that the turn insulation had crazed and that the failure occurred where a piece of phase insulation had not been placed properly. The motor still was insulated from ground, and it is believed that if this particular piece of phase insulation had been in place, the motor would have run much longer.

The third motor ran for 15 weeks when it failed by short circuit between turns and phases. The silicone film had crazed and allowed moisture to enter and to creep around a short piece of phase insulation. Again the process of applying experience was employed and a larger number of motors built. *Fig.* 5 shows one of these machines and some of the parts from which it was constructed.

TABLE II

Power Factor of Silicone Resins

(60 Cycles-500 Volts)

Type of Resin	Temperature (Degrees Cent.) 25	100	150	200
A	.003	.003	.005	...
B	.005	.001	.001	...
C	.004	.004	.004	.007
D	.001	.002	...	...
E	.031	.024	.069	...

These machines have been subjected to long periods of running at high temperature interspersed with shut-down periods in atmospheres of 100 per cent humidity, doused with oil, sprayed with carbon dust, cleaned and given high potential tests. These cycles, selectively arranged, have been carried on sometimes for months, until a weakness showed up. However, failures have been phenomenally low. Organic insulations given similar treatment survived only a fraction of the time.

A number of experimental synchronous machines have been constructed, one of which is of particular interest. This machine is a 75-hp, 450-rpm, 440-volt motor with armature coils employing several different types of construction of silicone insulations and a field winding with silicone-impregnated coils. Its operating history is briefly summarized in TABLE III.

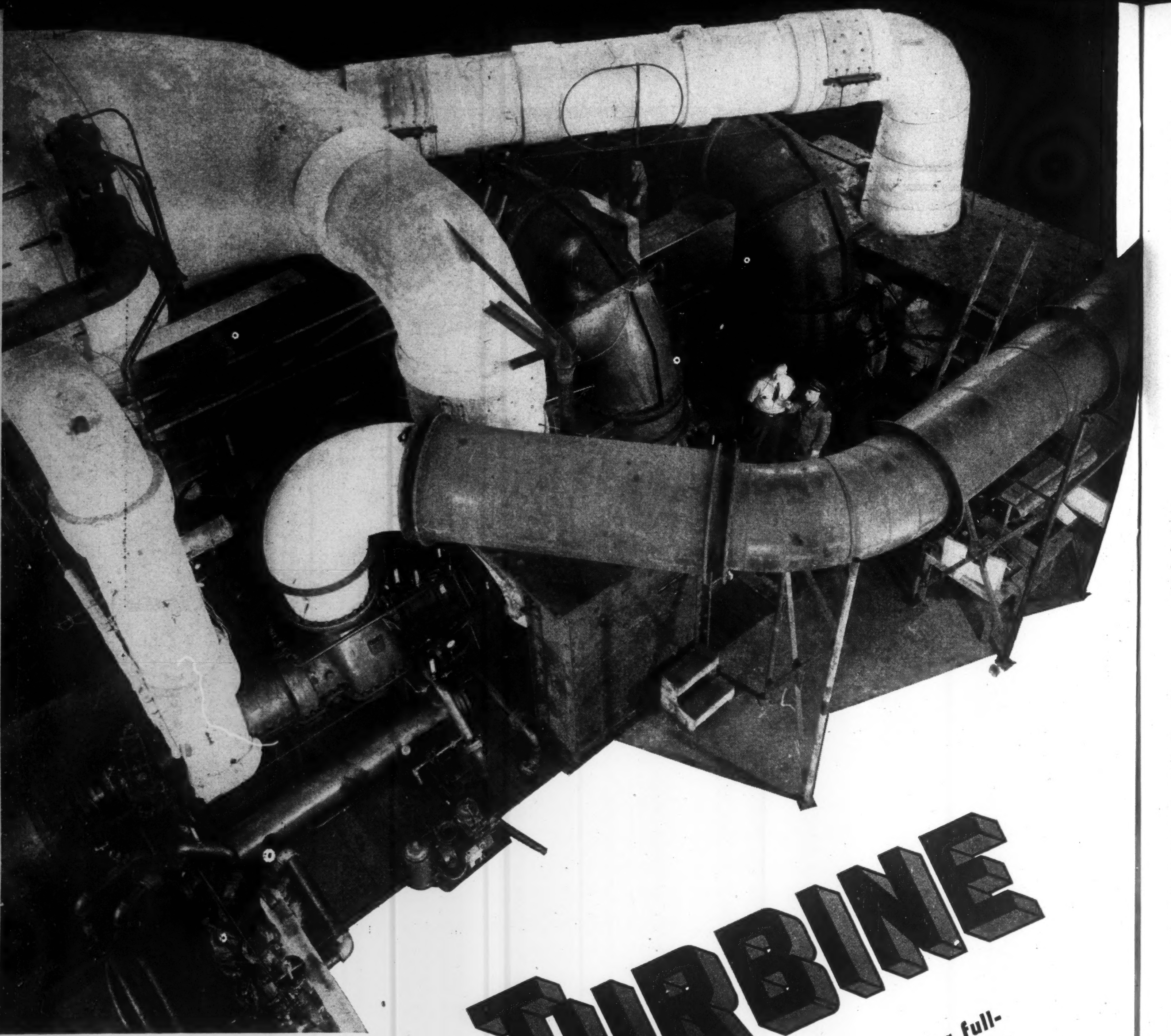
TABLE III

Operating Life of Synchronous Motor

Time (Hours)	Temperature (Degrees Cent.)
908	Below 175
149	175
1014	200
2429	250
300	300

Based on the 10 C deterioration rule the service on this machine was equivalent to 183 years of operation at 175 C, or 32.3 years at 200 C, or one year at 250 C.

Experience with silicone-insulated machines and with parts for those machines has, on the whole, been satisfactory from an insulation performance standpoint. Silicone, however, is not a panacea. Its successful application will require much study and experience. Its introduction into new machines should be made in an evolutionary manner, with experience built upon experience, ever extending its field after careful and thorough study of its merits for the particular application. In some cases sacrifices in efficiency and other machine operating characteristics will be necessary. In many cases economic problems will be encountered. In short, this new material poses intriguing problems whose solution will require sound engineering.



GAS TURBINE

. . . experimental power plant provides, under full-scale conditions, answers to many design problems

RECOGNIZING the need for a gas turbine unit capable of testing high-temperature materials under actual full-scale service conditions, the Bureau of Ships of the U. S. Navy some time ago arranged for the Allis-Chalmers Mfg. Co. to design and construct a 3500-hp experimental gas turbine unit capable of operating at temperatures up to 1500 F. Installed at the U. S. Naval Engineering Experiment Station at Annapolis, the unit, *Fig.* 1, has been under test for about two years, operating at progressively increasing turbine inlet temperatures, and has just recently completed a series of test runs at 1450 F, the highest operating temperature ever reached in a sta-

Fig. 1—Opposite Page — Experimental gas turbine power plant under test at Annapolis. Actual turbines are dwarfed by the piping and regenerator

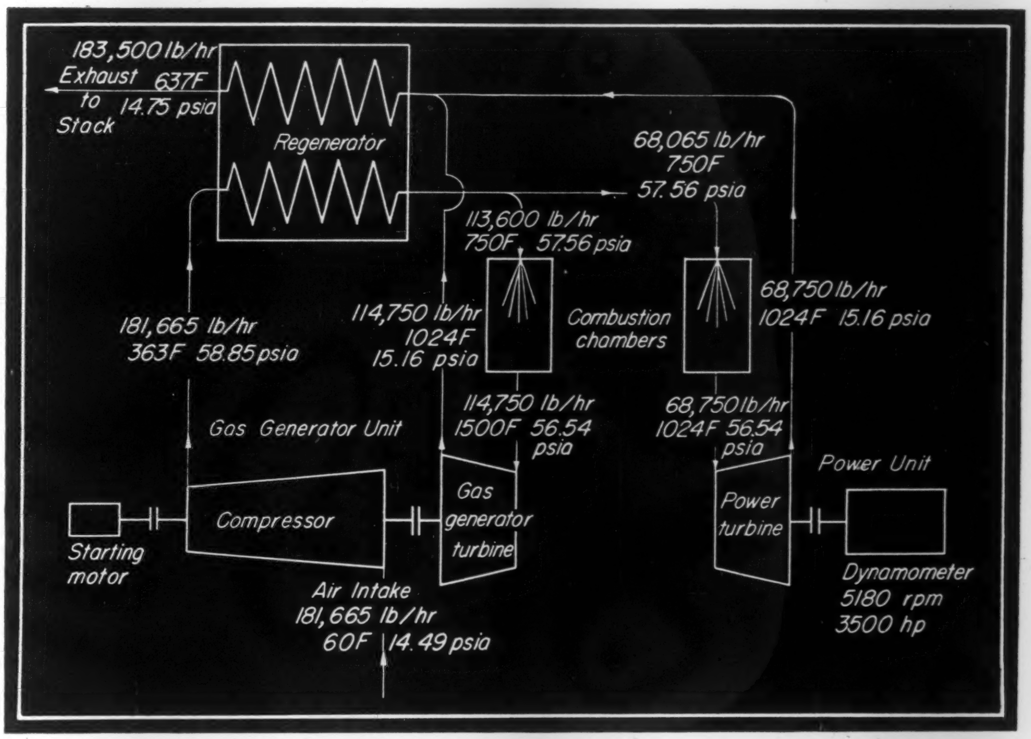

183,500 lb/hr
Exhaust 637F
to 14.75 psia
Stack
Regenerator
68,065 lb/hr
750F
57.56 psia
113,600 lb/hr
750F 57.56 psia
181,665 lb/hr
363F 58.85 psia
114,750 lb/hr
1024F
15.16 psia
Combustion chambers
68,750 lb/hr
1024F 15.16 psia
Gas Generator Unit
114,750 lb/hr
1500F 56.54
psia
68,750 lb/hr
1024F 56.54
psia
Power Unit
Starting motor
Compressor
Gas generator turbine
Power turbine
Air Intake
181,665 lb/hr
60F 14.49 psia
Dynamometer
5180 rpm
3500 hp

Fig. 2 — Right — Schematic diagram shows regenerative cycle utilizing two turbines in parallel. Figures apply to full-load operating condition

tionary gas turbine power plant of this size.

Objectives: Primary objective of the test program was the acquisition of design information concerning the essential component parts of a gas turbine power plant—turbines, compressors, combustion chambers, and heat exchangers. Although the gas turbine itself is basically the same as a steam turbine, the problems of detail design are considerably more difficult due to the higher operating temperatures. A modern high-temperature steam plant cycle operates with exhaust or terminal temperatures below 100 F due to the condensable property of water. Since the exhaust gas from an open-cycle gas turbine cannot be condensed, it ordinarily leaves the turbine at from 500 to 1000 F and approximately atmospheric pressure. Because thermal efficiency is proportional to the temperature drop, the higher exhaust temperature requires that the initial turbine inlet temperature adopted in the gas turbine cycle be considerably above the present temperature of 950 F employed in steam cycles. The present outlook for the application of gas turbines to marine propulsion and for other power uses indicates that such turbines must be designed to operate reliably at initial temperatures up to 1500 F if an attractive efficiency level is to be attained.

Existing applications of gas turbines include two classes of units in which an outstanding measure of success has been achieved. One of these is the development of gas turbines to drive the air compressors for the Houdry process used in the cracking of crude petroleum in the production of high-octane gasoline. Under actual service conditions during the past eight years Allis Chalmers gas turbines driving Houdry equipment operated at temperatures less than 1000 F, so that field experience with these units does not provide an adequate background for the construction of gas turbine prime movers to operate at temperatures up to the 1500 F level.

On the other hand, gas-turbine-driven superchargers for bombers and fighter planes operated for acceptable periods of time at an inlet temperature of 1600 F. In like manner the gas turbines used in jet-propulsion engines have performed well at an inlet temperature of 1500 F. The gas turbines in these cases are designed to meet a specific military requirement in which the attainment of the objective is paramount and a relatively short service life has been acceptable.

Selection of materials in the detail design of gas turbine

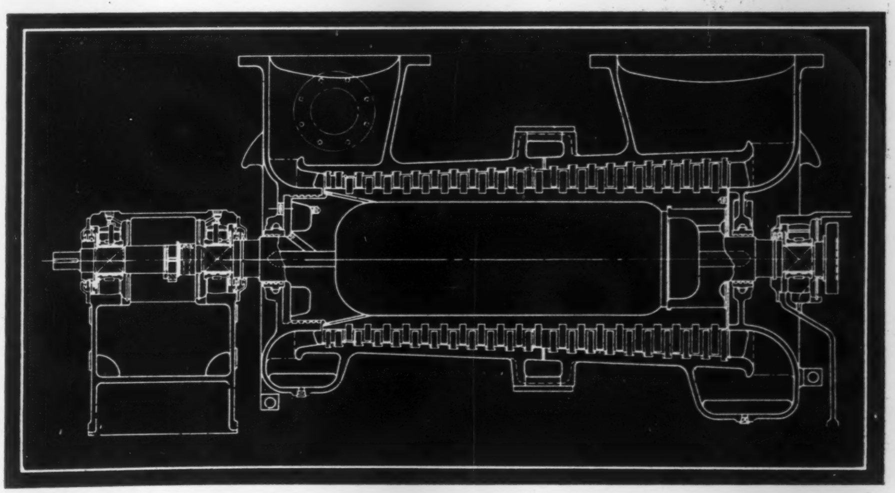


Fig. 3—Section through axial-flow air compressor, which delivers 40,000 cfm at 45 psi. It contains 20 stages of airfoil section blades

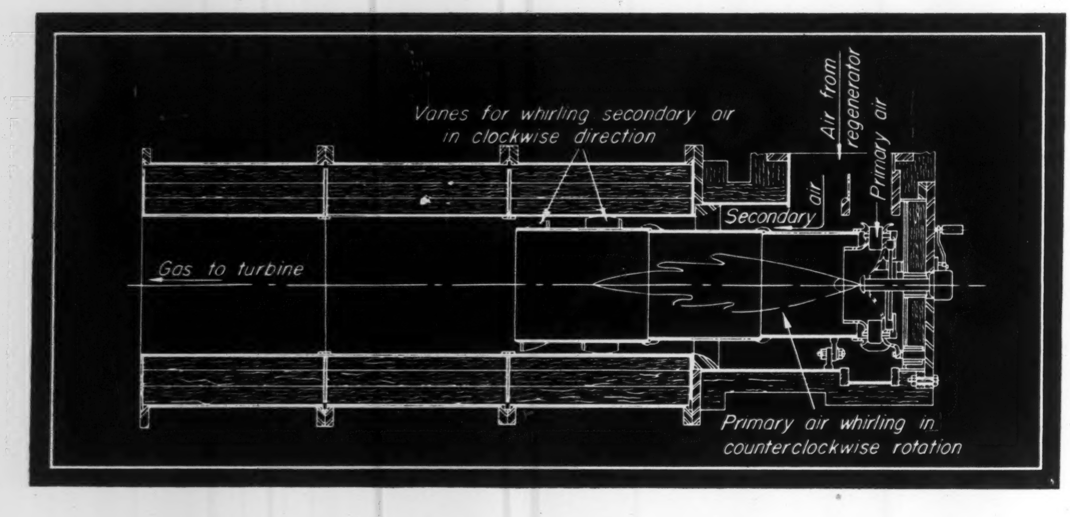


Fig. 4—Section through combustion chamber, showing flow of primary and secondary air

parts for high-temperature units built up to the present time has been based on laboratory tests of materials or on service experience with superchargers and jet-propulsion engines having relatively short service life. The experimental unit at Annapolis is designed to supply information on the practical service life of some of the new alloys in a full-scale turbine, operating at full temperature and under full-load conditions for considerable periods of time.

A further objective of the test was the determination of the operating characteristics of a gas turbine unit applied to marine propulsion. Because the gas turbine unit was entirely experimental, thermal efficiency was not given first consideration, although it was recognized that the ability to operate at higher temperatures would improve the efficiency of any gas turbine power cycle. In this project flexibility of operation, ease of taking essential research data at hundreds of points during each test run, and the facility of complete disassembly of any or all component parts for scheduled inspections as the tests progressed, dictated the arrangement of parts finally adopted.

Double Turbine Layout Employed

Cycle: The cycle selected involves the use of a parallel turbine arrangement, *Fig.* 2, one turbine driving the gas generator compressor and the second or power turbine driving the water brake or dynamometer which absorbs and measures the output power. This general arrangement is readily adaptable for use on board ship where the power turbine would drive the propeller through an electric transmission, by the use of a reversible pitch propeller, or by other mechanical means.

This cycle, *Fig.* 2, is known as the parallel turbine regenerative cycle. Air at atmospheric pressure enters the gas generator compressor where it is compressed to 45 psi gage pressure. The compressed air then enters the heat exchanger where it is heated by the turbine exhaust gas from a temperature of 363 F at the compressor discharge to a temperature of 750 F, at full load, at the entrance to the combustion chambers. After leaving the heat exchanger, the preheated air flows directly downward into the two horizontal combustion chambers, one of which supplies the gas generator turbine driving the compressor and the other of which supplies the power turbine. With this arrangement it is possible to control independently the power generated by the gas generator and power turbines, an operational advantage essential to shipboard operation.

Many of the problems encountered in the development and design of the 3500-hp experimental unit were without precedent. For example, the problem of thermal expansion alone required provisions in the combustion chambers, piping, and turbines for each foot of the metal to expand over one-eighth of an inch in all directions when heated to 1500 F and still remain pressure tight with an internal pressure of 45 psi. This movement had to be allowed without throwing any strains on the turbine casing. Provisions were also made to cool the bearing pedestals to prevent misalignment of the bearings during high temperature runs on the unit.

Compressor: In the axial-flow air compressor, *Figs.* 3 and 6, there are 20 stages of airfoil section blades, so arranged that the air is accelerated by the moving blades and then slowed down in the stationary elements in such a manner that part of the velocity energy is converted into pressure. This compressor runs at high efficiency, of the order of 85 per cent when compressing the full load volume of 40,000 cubic feet of air per minute against the operating head of 45 psi gage pressure.

Regenerator: Interposed between the compressor discharge and the combustion chamber inlet is the regenerator, or heat exchanger, which is designed to recover a portion of the heat in the turbine exhaust gas which would otherwise be lost from the cycle. This heat is absorbed by the high-pressure air on its way to the combustion chambers, and thus effectively reduces the amount of fuel required to raise the turbine inlet temperature to any desired value.

The regenerator is of the counter-flow type with the hot gas inside the tubes, and the high-pressure air on the outside. This design was intended to facilitate cleaning the tubes of any possible deposits on the gas side. The regenerator has an external heating surface of 8500 square feet, and is designed to have an effectiveness of approximately 60 per cent with relatively low pressure drops on the air and gas sides.

Combustion Chambers: A section through the combustion chamber, *Fig.* 4, shows that each of the two combustion chambers is supplied with a single oil burner in which the liquid fuel is broken up by mechanical atomization into extremely fine particles to promote rapid burning. The central flame tube is arranged to pass the proportion of the air flow necessary to support and complete combustion. Remainder of the air flows between the flame tube and the outer wall of the combustion chamber, thereby reducing the temperature of the flame tube to a safe operating level, and at the same time avoiding the use of refractory brickwork. The cooling air and combustion gases are then intimately mixed by allowing the oppositely whirling concentric streams to come together at the end of the flame tube.

Heat release in these combustion chambers at full design load is approximately 2,500,000 Btu per cu ft per hr, which is several times the heat release of the ordinary high-capacity central station boiler. The present unit is operating with No. 2 furnace oil. This class of oil distillate was adopted for the initial experimental tests because of its availability at the Experiment Station. In an ultimate installation it is predicted that fuels of grades as low as bunker C fuel oil will be used. Future plans for land installations contemplate burning powdered bituminous coal.

Turbines: The gas turbine which drives the axial-flow compressor is substantially the same as the one that drives the water brake or dynamometer except that the compressor or gas generator turbine has somewhat longer blades and is supplied with an air-operated internal bypass that is opened when starting. Each turbine, *Fig.* 5, has five pressure stages and operates at 5200 rpm at full load. The first two stages are of the impulse type in which the expansions from the upper to the lower stage pressures are substantially completed in each stationary ring of nozzles which directs the high-velocity gases on to the crescent-shaped moving blades. A diaphragm carries the nozzles that separate the first and second impulse stages. Last three stages are of the conventional reaction type.

Of particular interest is the method employed for cooling the face of the high-temperature turbine wheel. Air is carried through the outer of the two cooling tubes, shown at the right of *Fig.* 5, to a disk adjacent to the side of the high-temperature wheel. A series of holes in the periphery of this stationary disk directs the cooling air to the side of the first-stage turbine wheel. The cooling air then passes radially inward over the side of the disk and thence out through the center pipe to a water-cooled heat exchanger from which it is returned to the outer cooling duct by a positive-pressure blower. By this means there is effective cooling of the turbine disk without the loss of power that would otherwise result from the use of air pumped directly from atmospheric pressure to the first-stage pressure.

Both Sides of High-Pressure Wheel Air Cooled

In like manner, cooling air is introduced around the periphery of the second-stage diaphragm. It is led through radial holes to an annular passage around the center portion of the diaphragm, and then passes through a series of holes that allow the cooling air to blow on the downstream side of the high pressure wheel. The cooling air is supplied in sufficient quantity to equal, approximately, the leakage of the diaphragm labyrinth seal. Thus the high-temperature turbine wheel is effectively blanketed against the weakening effect of the high-temperature gas.

Blades and disks of the turbines are constructed of a recently developed high-temperature Timken alloy steel, which includes 16 per cent chromium, 25 per cent nickel, and 6 per cent molybdenum. This was developed for use particularly in the Annapolis unit, and has also had exten-

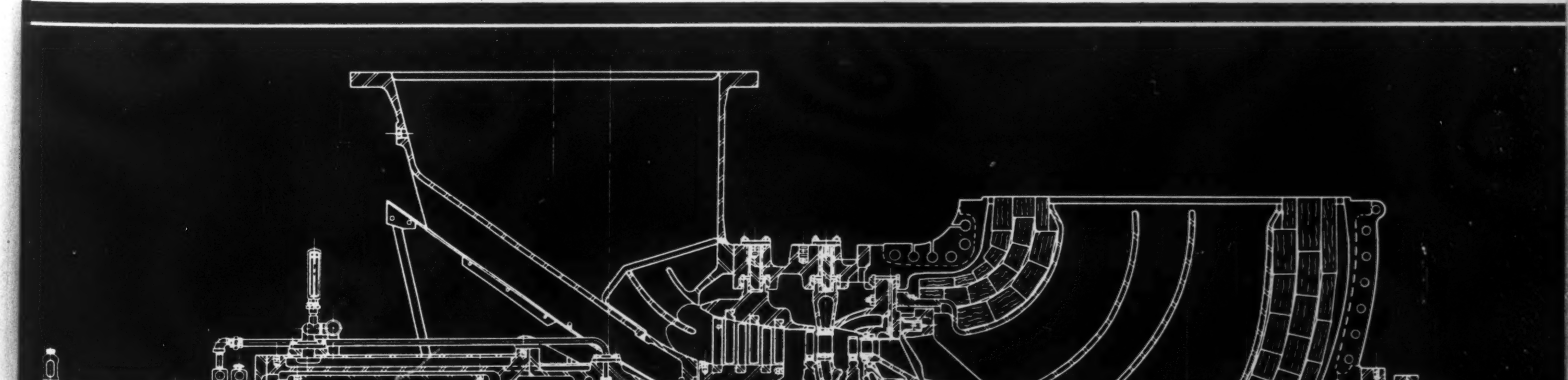


Fig. 5—Assembly of gas turbine, showing the method employed for cooling the high-temperature wheel

sive service in superchargers and jet-propulsion engines during the recent war. The heavy stationary parts of the turbines are made of an alloy steel containing 25 per cent chromium and 12 per cent nickel.

Turbines and compressor use sleeve bearings throughout with pressure lubrication, the oil being cooled and cleaned continuously during operation of the unit. The turbines are also equipped with emergency overspeed and over-temperature trips which automatically shut off the fuel supply and at the same time open up an atmospheric relief valve in the high-pressure air line ahead of the combustion chambers.

Piping: In a gas turbine power plant of 3500-hp capacity, enormous quantities of air and hot gases are continuously circulating through the system, requiring large pipes. The air intake pipe in the Annapolis unit is 36 inches in inside diameter, and the exhaust opening of the gas generator turbine is 42 inches in diameter in spite of rather high gas velocities. Pipes leading from the combustion chambers to the turbines, *Fig.* 1, appear large because the insulation necessary to withstand the hot gases at 1500 F is between the double-wall construction.

Protecting Pressure Piping from High Temperature

In the large high-temperature piping, an internal gas guiding tube is installed with a space of approximately 9 inches between the internal guiding wall and the outside pipe. This space is filled with mineral block insulation resembling fire brick. By this means it is possible to keep the outer pipe walls down to a temperature level where the full physical strength is available.

The swing-type expansion joints installed in the piping are of major importance due to the great amount of thermal expansion that takes place between room temperature and the high initial temperatures at which the unit operates. These joints consist of a series of radially placed hinges between the flanges, the arrangement being such that the rotation of the adjoining members operates to relieve the dimensional changes of the piping resulting from thermal expansion without the distortion of turbine and compressor parts that would otherwise occur. Piping supports also were designed to allow thermal expansion without permitting the expansion forces to affect the interconnected elements.

Starting: The unit can be started with less than 100 horsepower by means of an electric motor connected to the compressor unit by a clutch. At the starting speed of approximately 25 to 35 per cent of full-load speed, the starting motor is disengaged and the fuel is ignited in the combustion chambers. The unit can then be brought up to full speed by manual fuel control.

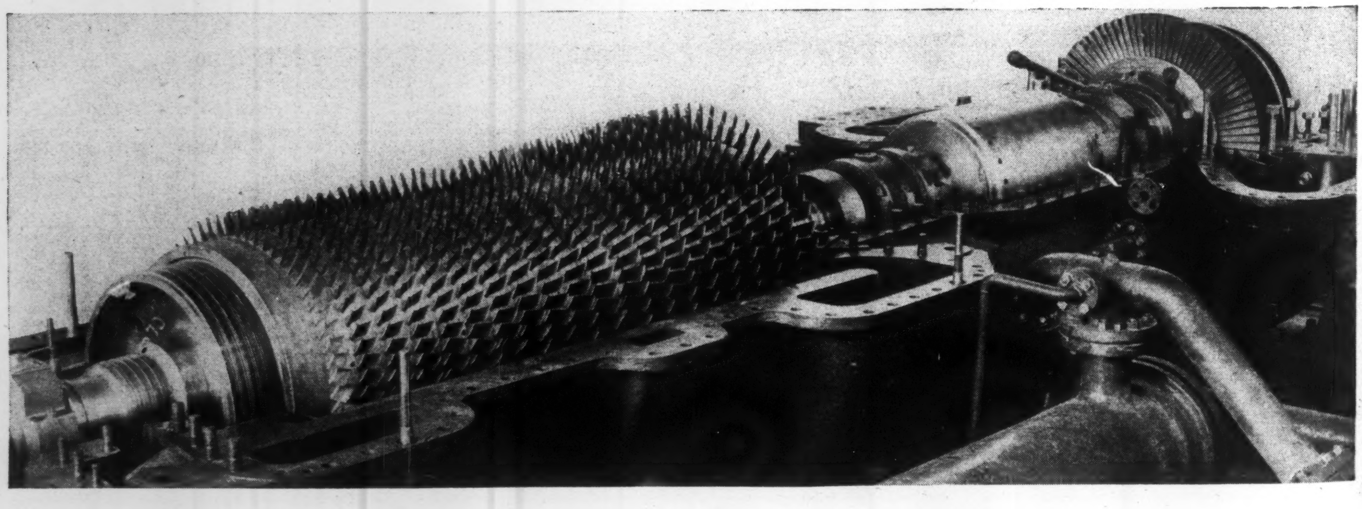
Testing: Test plans include the operating of the unit for established periods of time under prearranged operating conditions, with gradually increasing turbine inlet temperatures. Each test operating period is followed by complete disassembly and full inspection, with numerous measurements to determine what changes in high temperature parts have taken place. Examinations following these test periods have included a thorough search for the development of any possible cracks, and also observations of the resistance to oxidation of the high-temperature parts.

With the two-shaft arrangement it is possible to operate the gas generator turbine and the power turbine at different speeds, pressure ratios, and rates of gas flow, thus determining the characteristics of the turbines and the axial-flow compressor over a wide range of conditions. A throttle valve installed in the high-pressure air line just ahead of the power turbine combustion chamber permits regulation of the flow through that turbine for separate load and speed regulation.

Applying the data obtained from the testing of this high-temperature unit, it is estimated that an overall plant thermal efficiency of 40 per cent at 1500 F could be obtained with a modified gas turbine plant of this size for marine application. In the modified plant, the air compressor would be built in two elements with intercooling between the high and low pressure sections. The turbines would be in series, instead of parallel, with reheat at the inlet of the low-pressure element. In the future top-efficiency installation, the regenerator surface area would be several times that now installed in the Annapolis plant.

It is to be expected that any new type of unit so radically different from former power plants as the present one must undergo substantial changes before there can be extended service application. On the other hand, it should be pointed out that the present unit has a good operating history up to the present time with only a few minor mishaps to mar an otherwise perfect record.

Fig. 6—Compressor and turbine with covers removed. Pressure-lubricated sleeve bearings are employed



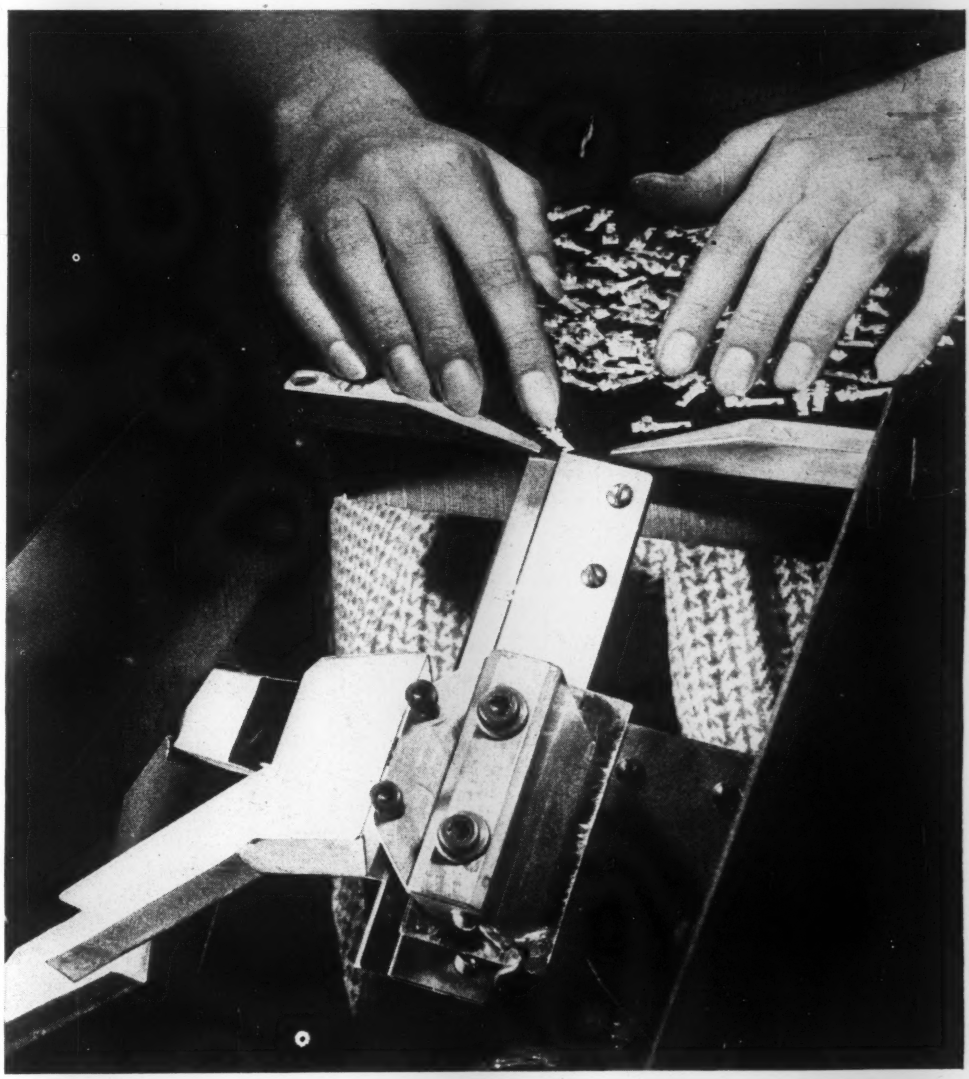


Fig. 1—Light-contact energization of solenoid kick-off mechanism through electronic relay makes possible fast sorting by size of small metal parts

Electronic relays

. . . provide control for machine elements from electrical impulses or mechanical pressures too minute for reliable operation by conventional methods

By Karl Keller
Manager, Akron Office
General Electric Company

MACHINE DESIGNERS often must meet the problem of initiating automatic operations from the position or motion of lightweight or extremely flexible materials which cannot support or transmit mechanical forces required to operate conventional mechanical latches or electrical controls. Many solutions to such problems are solved through the use of electronic contact-amplifying relays. Such relays are designed

Fig. 2—How parts sorter shown in Fig. 1 operates. Extremely small contact currents at A and B are boosted by electronic amplifying relay to power required for actuating solenoid kick-offs

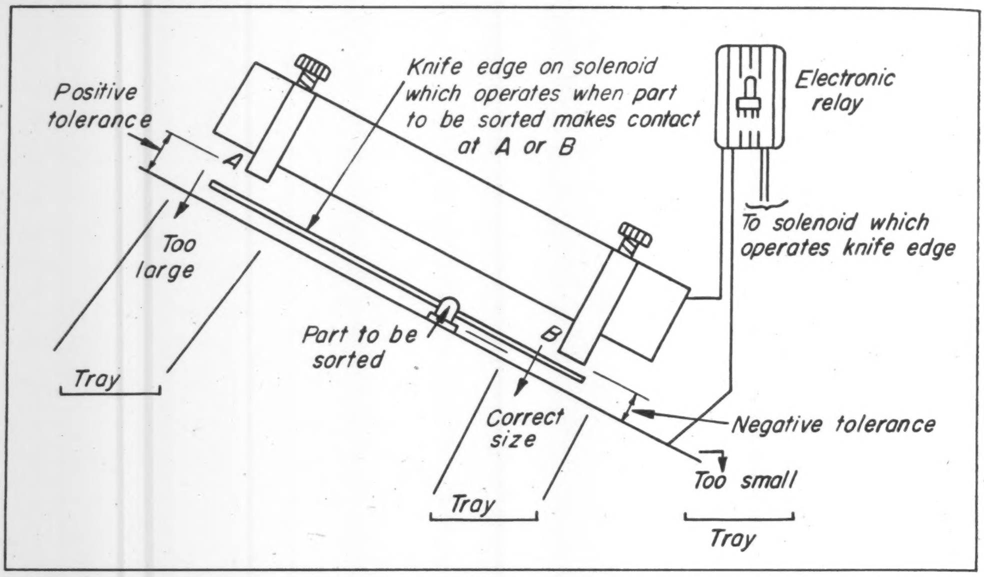

Positive tolerance
A
Knife edge on solenoid which operates when part to be sorted makes contact at A or B
Electronic relay
To solenoid which operates knife edge
Too large
Tray
Part to be sorted
B
Correct size
Tray
Negative tolerance
Too small
Tray

Fig. 3—Below—Typical electronic amplifying relay. Such relays sometimes control power amplifications of over 1,000,000 times

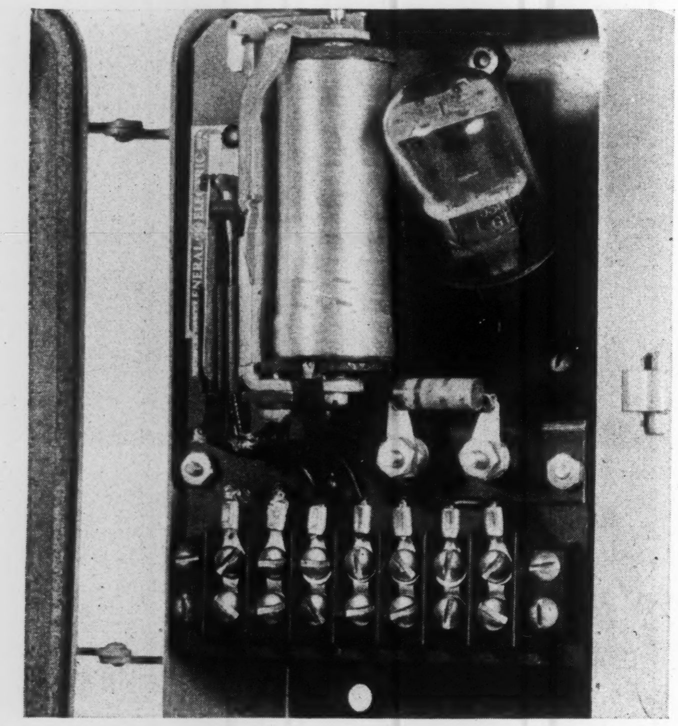
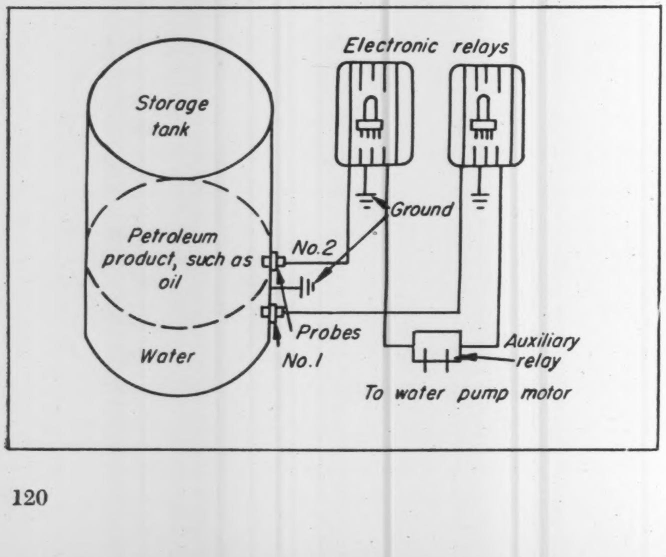


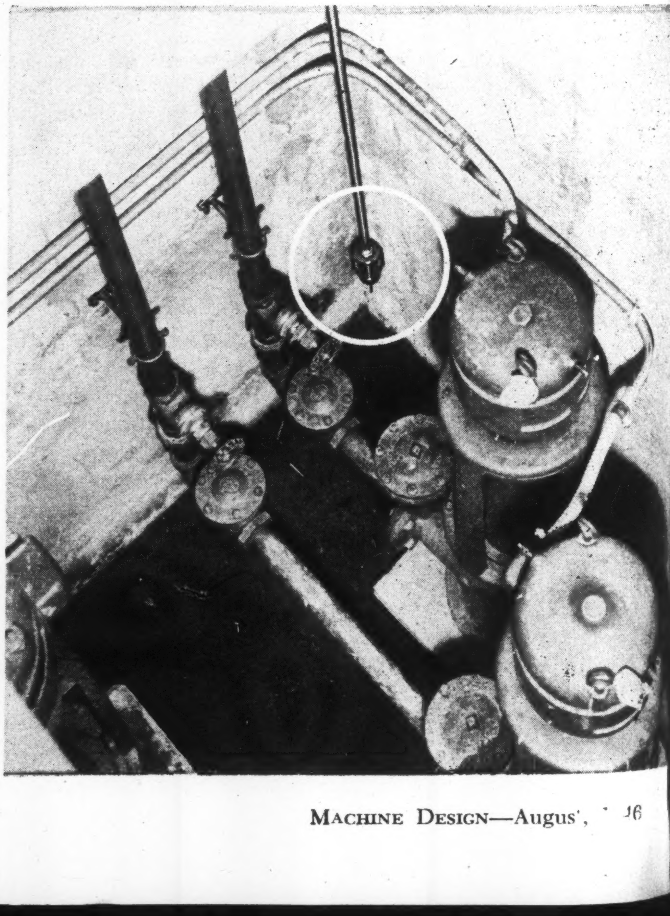
Fig. 4—Below—How electronic relays are used in conjunction with probes to control liquid level in a tank


Electronic relays
Storage tank
Petroleum product, such as oil
Water
No.2
Ground
Probes
No.1
Auxiliary relay
To water pump motor

to operate from minute signals which can be created by the motion of the lightest and most flexible material and, through the amplifying properties of the relays, can control automatic machine operations through conventional electrical devices such as solenoids, valves, motor starters, etc.

Electronic contact-amplifiers are designed to operate from low-energy signals of less than 0.0001-watt, and transform this signal quickly into the operation of electromagnetic relays capable of controlling up to 100 watts; an amplification of over 1,000,000 times. The relays will respond under certain conditions to signals as short as 0.004-

Fig. 5—Below—An electronic relay serves as liquid level control in a pumping chamber (see schematic, Fig. 4)



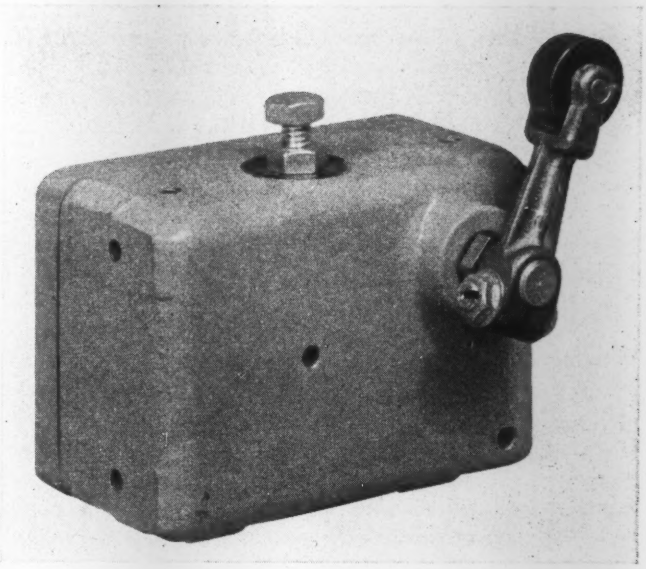


Fig. 6—Right—This switch, operating on displacements as small as 0.002-inch and force of only eight ounces is used extensively in conjunction with electronic relays

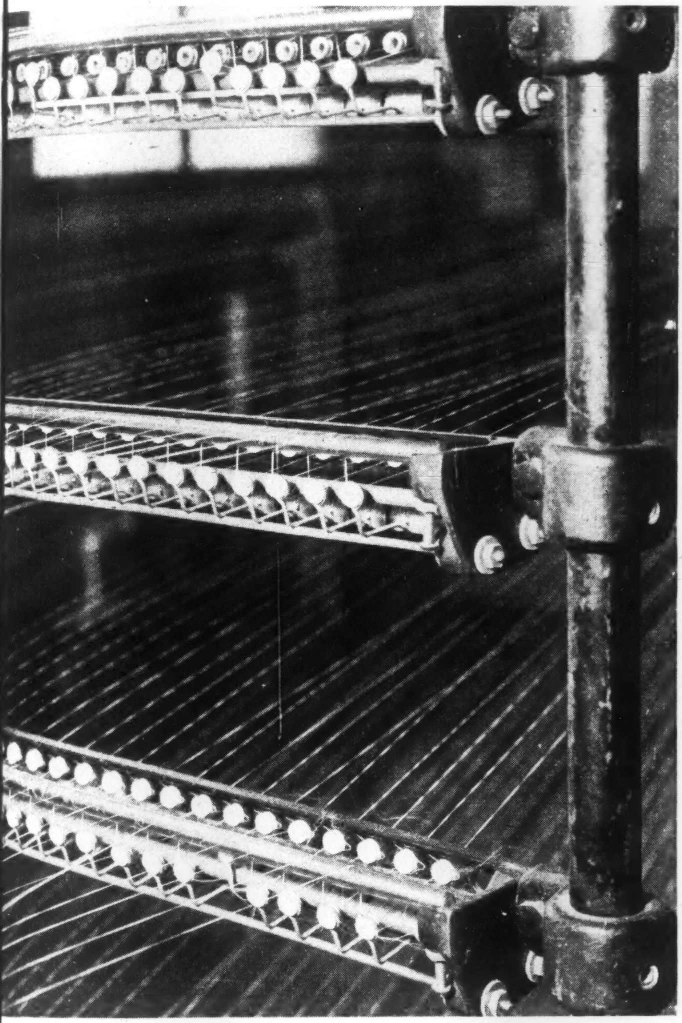


Fig. 7—Above—Creel take-off in a textile machine showing threads passing through eyelets, holding them away from contact bar

second duration and will operate at rates of several hundred times per minute.

When the materials whose position or motion is to initiate the machine operation are semielectrical conductors, the materials themselves can be used to initiate the control system. This is accomplished through contact with lightweight, low-inertia contact fingers, properly located to make or break contact with the work material as it reaches the position at which the automatic operation is to take place. Such materials can easily support and transmit the low-level electrical energies required to actuate the relay accurately and dependably, with practically complete absence of electrical or mechanical stress or strain on the work material.

A typical application of the electronic contact-amplifier in a machine designed to automatically sort metal screw-machine parts is shown in *Figs.* 1 and 2. Parts that are too large make contact at *A* and cause the electronic contact-amplifier to operate a solenoid kick-off mechanism

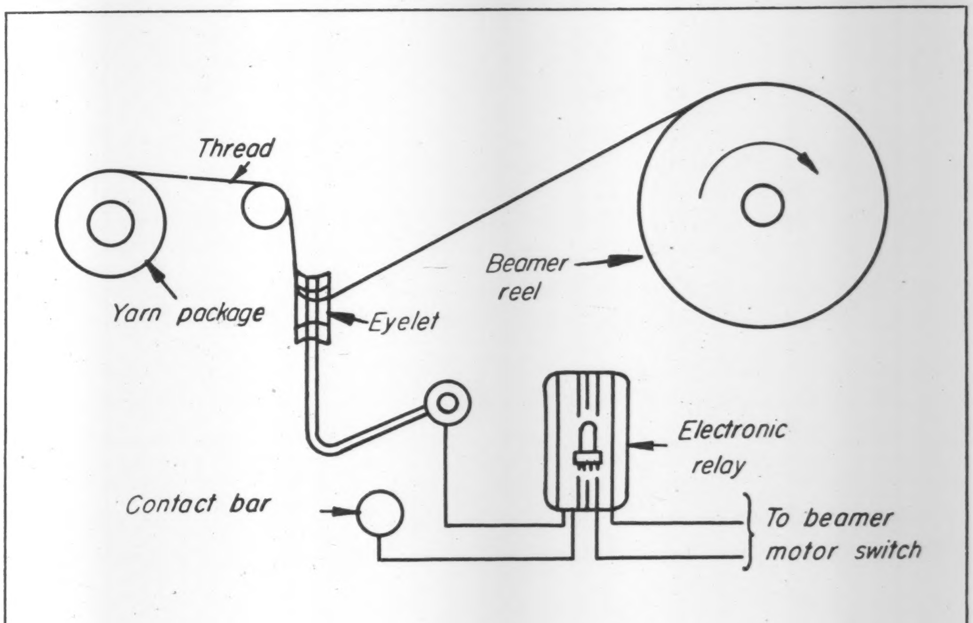


Fig. 8—Right—Schematic of creel take-off system. If thread breaks, eyelet arm drops on contact bar. Resulting contact current energizes the electronic relay

which quickly rejects the part. Parts that get past this point are either within acceptable limits or too small. If the part is of correct size, it will make contact at *B*. The electronic relay at this point will operate a second solenoid kick-off mechanism and the part will be routed to the proper tray. Parts that are too small will slide on through. Contact currents are so small that they cannot mar the most highly finished surface. An electronic amplifying relay such as is commonly used in such applications is shown in *Fig.* 3.

Another application is where the controlling signal passes through the work material. For example, the operation of a fine-wire tensile-strength testing machine is required to stop at the instant the sample breaks. A low-energy electrical circuit is established through the wire, the ends of which are connected to the control terminals of an electronic contact-amplifier. At the instant the wire separates the electric circuit is broken. Being a low-energy circuit there is complete absence of electrical arc or spark which might damage the surface of the break. However, the output circuit of the contact-amplifier interrupts several watts of energy in the motor starter control circuit to stop the machine.

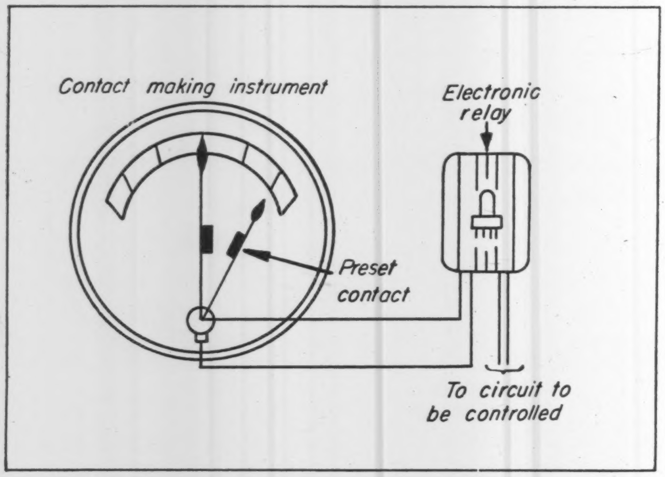


Fig. 9—Small current effective through contact-making ammeter can accurately control large power units with aid of electronic amplifying relay

Float switch control for liquid level utilizes direct contact with the liquids as illustrated in *Figs.* 4 and 5. This control can be used safely and effectively with semiconducting liquids such as distilled water, milk, etc. The relatively high resistance of the liquids presents no barrier to the application of these relays since they will operate dependably through circuits having as high as 5,000,000 ohms resistance. The low-energy electrical circuit established through the liquid will not support electrolysis or electrochemical reactions of any consequence. Thus this method overcomes one of the principal objections to the use of direct liquid-contact electrical systems in many liquid-level control applications.

Where nonconducting materials are involved, lightweight contacts actuated by the material can be employed to operate the electronic relay. If lightweight and flexible materials are involved, the mechanical forces which can be supported and transmitted through the materials often are limited to such a low magnitude that contact mechanism extremely light in construction and designed to operate with mechanical displacements of only a few thousandths of an inch must be used. Such switches often are limited in their application in conventional electrical control systems, because of the rapid deterioration of the contacts, even when handling only a few watts of electrical energy. However, when such devices are used in combination with electronic contact-amplifiers, they can control the low-energy-level power involved and the way is opened for their application with assurance of dependable and long-life operation.

Low-Displacement Switches Most Suitable

The switch illustrated in *Fig.* 6 is particularly adaptable for use with electronic contact-amplifying relays in such systems. It will operate with displacements as small as 0.002-inch, with displacing force of only eight ounces, and is used extensively for detecting seams in cloth in the textile industry.

In many high-speed limit-switch applications, use of conventional limit switches operated from high-speed cams with high rate of displacement results in short mechanical life. Much longer life is assured through the use of small lightweight low-displacement limit switches of the type shown in *Fig.* 6 operated in conjunction with electronic contact-amplifiers.

Application of an electronic contact-amplifier relay to a textile creel take-off system is shown in *Figs.* 7 and 8. Each thread from the creel passes through a lightweight eyelet and holds the eyelet away from a contact bar. If a thread breaks, the eyelet which it supports drops to the contact bar and establishes a contact with it. Because of the extreme light weight of the eyelet, the contact resistance is high and will not pass sufficient energy to operate electromagnetic devices which can be used to shut down the machine. However, the energy which can be passed by such a high resistance contact is ample for the control of an electronic system which, in turn, can be connected to control conventional electrical systems.

Application of contact-making ammeters and similar metering devices, to which only the lightest of contacts can be applied without affecting instrument accuracy, is also enhanced by the availability of electronic contact-amplifying relays. A contact-making ammeter designed for use with electronic contact amplifiers is shown in *Fig.* 9. The pointer carries a small contact which engages an adjustable stationary contact. The combination is connected to the control terminals of the relay which will make and break a contact of one-ampere capacity as the light instrument contact is opened and closed.

BEARING SIZE STANDARDIZATION would reduce overall costs, speed delivery of bearings, aid young industries and broaden American participation in world reconstruction. Ball and roller bearing manufacturers now produce and stock 40,000 sizes and makes of antifriction bearings, some of which differ from others by the merest hair's breadth, according to S. F. Wollmar, SKF Industries. About 2000 sizes would meet almost every industrial need without any sacrifice in quality.

Cyclic Cutting of Continuous Paper Webs

By H. C. Cook

WHERE operations such as printing, perforating, etc., are to be performed on a running web of paper, the question of cutting the web while it is traveling through the machine often presents difficulties, especially if a variety of types of cutting is required. Such operations are comparatively simple if the web is stopped momentarily in each cycle of the machine. In many instances, cutting is achieved by intermittently stopping the portion of the web to be severed while the main portion continues in motion. However, by use of the rotary-cutting couple, which was discussed in a recent article[*], simple severance may be effected without interfering with the uniform running speed of the web. Furthermore, other types of cutting may be achieved with the introduction of a simple mechanism applied to the device.

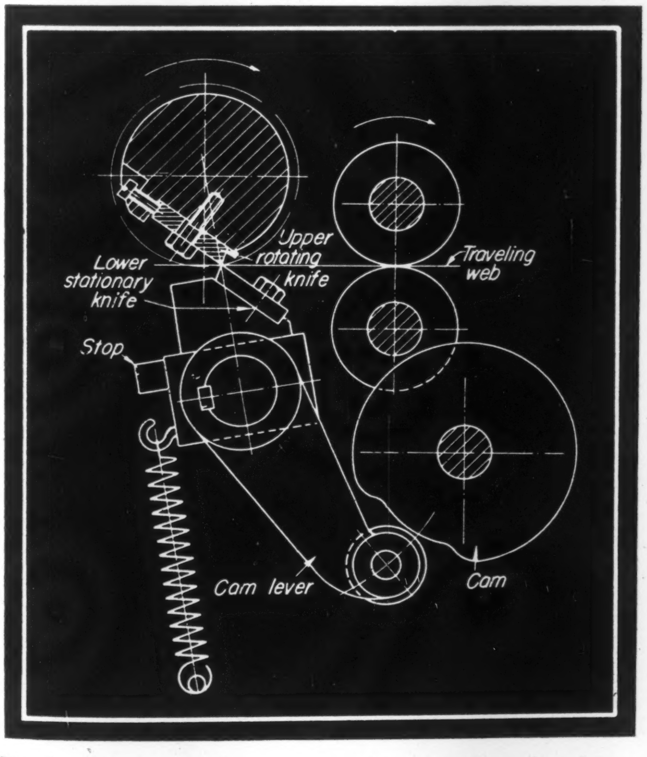


Fig. 1—Cutting couple is rendered inoperative when lower knife is pivoted away from cutting position

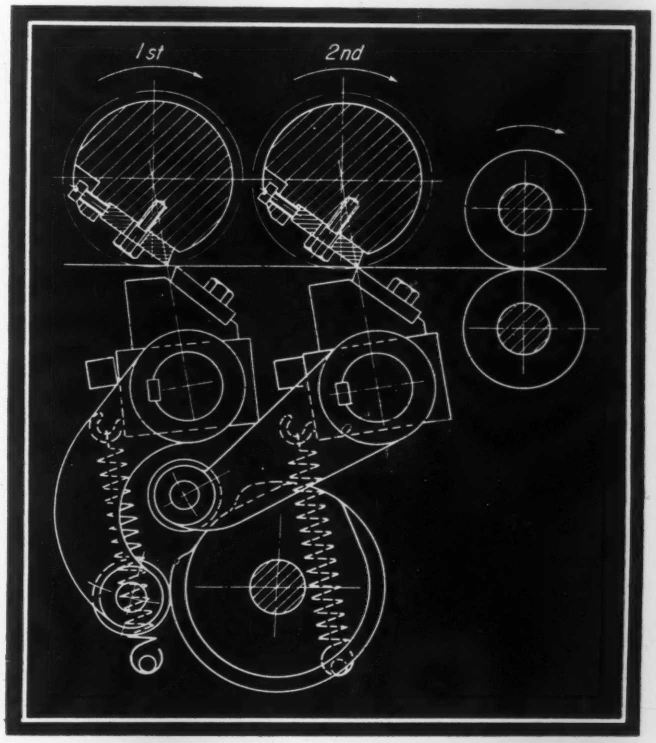


Fig. 2—First knife assembly severs web completely while the second has notched blade for incomplete severance

Problems of this type normally are found in the manufacture of tags, labels, etc. It is required sometimes to sever the web at each cycle of the machine to produce completely the article of manufacture. Again, with products of this kind, it is often required to produce them in ganged formation in view of subsequent operations which are more simply performed with the material in strip form.

An example is found in the production of labels in book form. In this case the web is printed and cut so that strips are delivered, each containing a multiple of print units. These strips are interleaved with the necessary parts such as covers, etc., stapled and then guillotined into separate, complete, finished books. It may be required to cut the strips in manufacture according to the unit size of these products. Thus the machine must be capable of performing such variations.

With the use of the rotary knife couple all that is required to accommodate these variations is an attendant mechanism designed to render the cutting couple inoperative for one cycle in each two, or for two cycles in each three, etc., according to the multiple of units required in each gang.

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[*] H. C. Cook—"Improving Design of Paper Cutters", MACHINE DESIGN, July 1945, Page 127.

A simple mechanism for effecting this is illustrated in *Fig.* 1. It will be noted that, according to this setup, the lower knife is mounted to pivot away from the operative position of contact with the upper knife. This movement is controlled by a cam which is contacted by a cam roller pinned to the cam lever which in turn is secured to the pivoted lower knife assembly. The camshaft is driven at a selected ratio of reduction according to the requirements of ganging. When the cam allows the lower knife to assume the operative position for severing the web, the cutting pressure is taken by stops, thus providing a positive and unyielding position for the action of cutting.

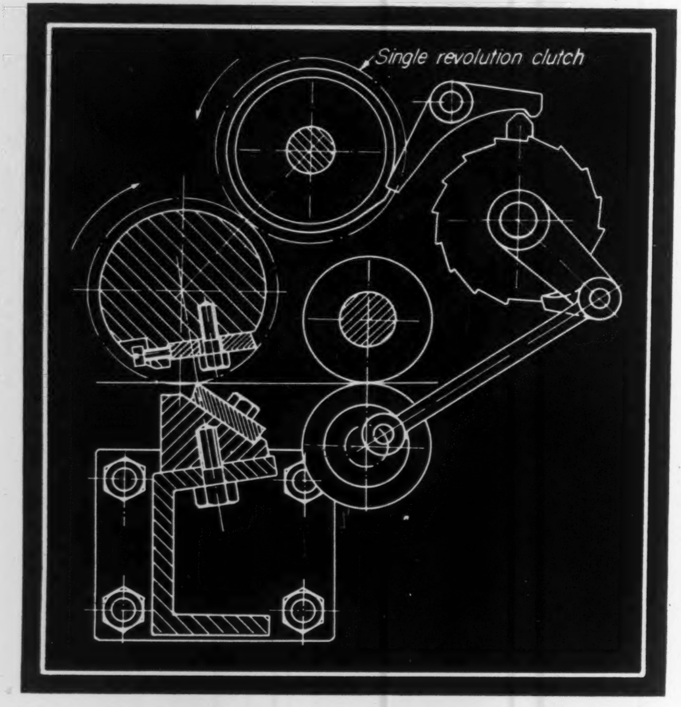

Fig. 3—Use of single-revolution clutch permits considerable length of web to run between cuts

When it is required to cut tags singly or in gangs, and where each unit is partially severed ready for simple detachment at some subsequent time, the setup shown in *Fig.* 2 provides a solution. Two separate rotary knife couples are each controlled by cams as in *Fig.* 1, but in this case the first knife assembly is arranged to sever the web completely while the second has the upper knife blade notched so that imperfect severance takes place at the appropriate locations.

In running a machine with this arrangement, the two lower knives are controlled for operative and inoperative positions in a sequence which allows the first couple to separate each gang of units from the web. For the divisions between the units which require interrupted severance, the second couple is caused to sever the web partially, and is then rendered inoperative at positions on the web subsequently completely severed by the first assembly.

Such an arrangement is easily made for ganging any number of units by running the camshaft at a definite reduction ratio according to requirements. A further development of the same idea makes it possible to sever long lengths of web at predetermined intervals by arranging the camshaft ratio accordingly.

Where the lengths required are so considerable as to make this arrangement of a reduced camshaft speed an impracticable proposition, an alternative may be used as shown in *Fig.* 3. Here the upper knife is arrested in its rotation and allowed to make one revolution for severing the web when required. This operation is controlled by a "one-revolution" clutch connected in the drive to the upper knife. This in turn is controlled by a counting device or similar arrangement. For instance, the web may be measured by a contact roller which, after a predetermined number of revolutions, causes the clutch to trip. As is usual with this type of device, the clutch is reset at the completion of one revolution.

The foregoing examples of the application of supplementary mechanisms to the rotary cutting device will give some idea of the possibilities of advancement in methods and may indicate the possible trend of improvements resulting from the adoption of this method of cutting.

Crashing the Sonic Barrier

IN THE near future a pilot will take off in an airplane on what is perhaps the most important mission an airman has undertaken since man's first flight. His plane, the XS-1, will look like no ordinary craft and will be even more revolutionary than it looks. His mission will be to smash the stonewall supersonic barrier and to attain supersonic speed.

Supersonic speed, technically, is any speed greater than that of sound—approximately 760 miles per hour at sea level—but for convenience, speeds from 600 to 900 miles per hour have been designated as transonic speeds, and may be thought of as the sonic barrier. If an airplane can crash through the transonic range, there is no known limit to the speed it may attain.

The problems of getting through the sonic barrier safely are many. Probably the first is the matter of power. At 600 miles per hour, the lower limit of the transonic range, the curve representing drag versus speed becomes almost a perpendicular line. Because drag at a given speed decreases as altitude increases, transonic and supersonic flight will be carried out at extreme altitudes.

The XS-1 will be rocket-powered when it takes off on its historic mission. Rocket engines require no outside air but carry their own oxygen along with them, which will enable the plane to fly to altitudes where the air is so rare that conventional turbojets or even ram jets could not operate efficiently.

In the strictly technical sense the XS-1 already has flown, but not at transonic speed and not under its own power. It has been taken into the air, released, allowed to dive and glide, and has passed these preliminary tests successfully. Test pilots know its stalling speed, control correction and landing technique. At 30,000 feet and an air speed of 350 miles per hour the plane, with its ultrathin wing and tail surfaces and its clean design, handled beautifully, showing no vibration or noise.

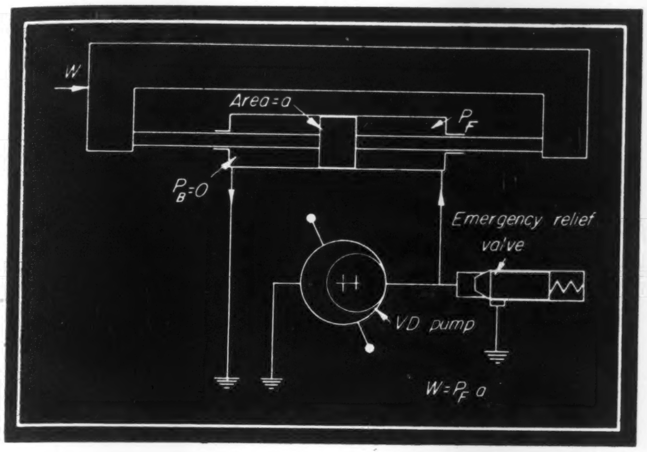

Fig. 20—Simplest type of variable-delivery pump circuit, with reversal provisions omitted

Machine Hydraulics

By Albert H. Dall
Assistant Research Director
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Part III—Variable-Delivery Circuits

IN THE previous articles on hydraulic feed rate control systems (M. D., April and June, 1946), the constant-delivery type of pump was employed as the hydraulic power source. In these systems, it was necessary to by-pass part of the pump delivery in order to obtain feed rates below the maximum. When a variable-delivery pump is used, it is no longer necessary to shunt part of the oil to change the feed rate, the delivery of the pump itself being changed to obtain changes in feed rate.

Many types of variable-delivery pumps are available commercially for these purposes. Most of these pumps are of the multi-piston type in which the stroke of the piston is varied by mechanical means such as an eccentric. Some are made with the pistons disposed radially inside an eccentric ring, while others are made with the pistons parallel to the axis of rotation. Still other types of commercial variable-delivery pumps are on the market, including piston type pumps with phase-changing cams, and vane type pumps.

It is not within the scope of this article to discuss the

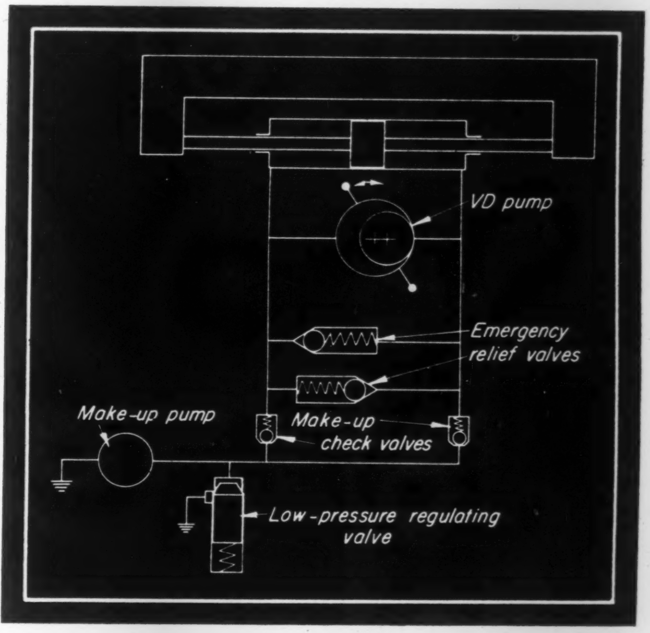
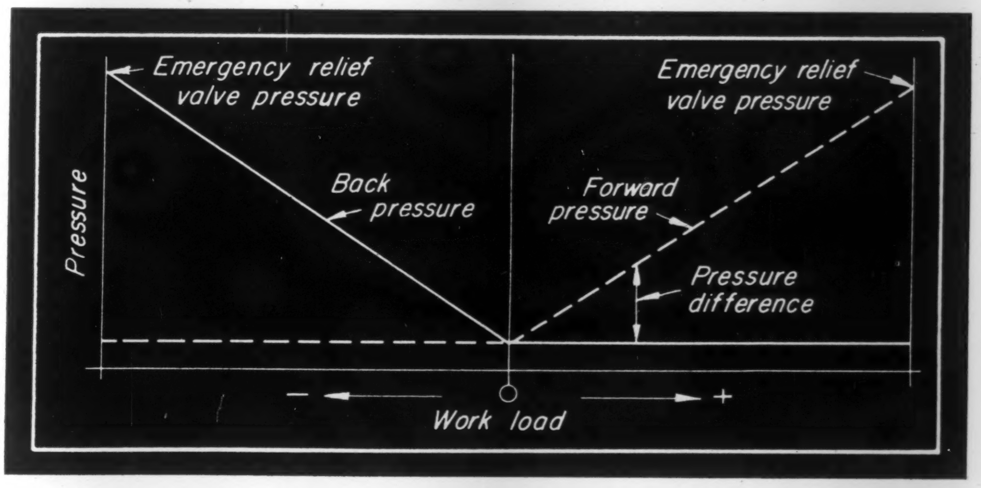


Fig. 21—Above—Variable-delivery pump circuit in which flow through pump is reversed to provide feed reversal

Fig. 22—Below—Pressure variations due to changes in work load for the circuit shown in Fig. 21



relative merits of the various types of variable delivery pumps. However, it should be pointed out that if the efficiency of a pump varies directly with delivery at constant pressure, the power input to the pump will be constant and there would be only a slight advantage in the use of a variable-pump circuit over that of a constant-delivery pump circuit. Thus, before employing a variable-delivery pump circuit the designer should weigh the gain in efficiency against the increased cost, inasmuch as the performance of throttle circuits as discussed in previous articles compare very well with the variable-delivery pump circuits.

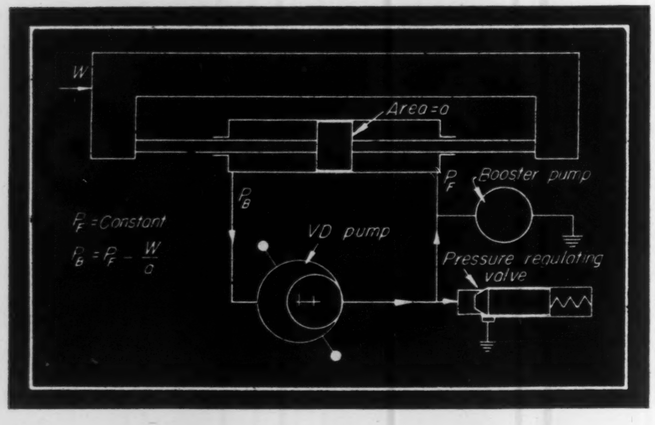
Simple Variable-Delivery Circuits: Variable-delivery pump circuits are usually much simpler than throttle-control circuits since the function of flow control by valves is not necessary. The simplest type of variable-delivery pump circuit is one which requires almost no valves except distributional valves such as a reversing valve, etc. *Fig.* 20 shows the simplest type of circuit. In this circuit, the forward pressure rises to a value sufficient to overcome the work load. The constancy of feed rate under various loading conditions is dependent on the pump slip only. In a well-made pump the slip resistance may be as high as 50 units, i.e., 2 cu in. per min slip per each 100 psi pressure difference. Leakages out of the forward pressure line, such as slip past the piston, will cause the rate to reduce with increased work load at any given pump displacement.

Reversing Pump Requires Closed Circuit

In *Fig.* 21 is shown a circuit in which the pump is used as a medium of reversal. Neither side of the pump can be directly connected to the reservoir, as in *Fig.* 20, because the reversal feature could not be used. Thus a closed circuit must be used and both sides of the pump are connected to a low capacity make-up pump through check valves. In any closed circuit it is necessary to make up the leakage, however small, out of the circuit. In the circuit of *Fig.* 21 any leakage from the forward pressure line will result in a diminished rate. Therefore the supply to the suction side of the pump will be reduced, causing a drop in pressure to a point where the make-up check valve will lift, causing flow from the make-up pump to the suction line.

This circuit is capable of supporting negative work loads (loads which assist slide movement) as well as positive loads (loads which resist slide movement). In the case of negative loads, the back pressure will rise and leakages out of this line will obviously cause an increase in rate which will in turn drop the forward pressure to the pressure of the make-up pump. *Fig.* 22 shows the pressure variations with work load.

Fig. 23—Circuit with constant forward pressure, which requires expensive high-pressure booster pump



Constant Forward Pressure Variable-Delivery Circuit: In the two preceding circuits, *Figs.* 20 and 21, the forward pressure varies with positive work load. With a different arrangement of make-up pump, it is possible to control the loads by back pressure changes. *Fig.* 23 shows such a circuit. In this circuit the make-up pump is called a booster pump and is used to supply the forward pressure line in addition to its normal supply from the variable-delivery pump. Thus some means of by-passing the excess must be provided. A spring-operated pressure regulating valve is shown for this purpose.

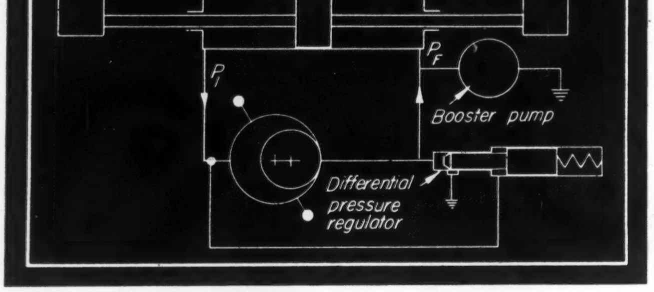
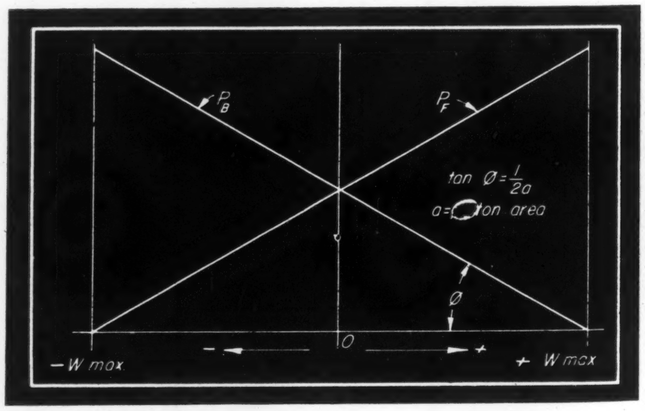


Fig. 24—Above—Variable-delivery pump "locked" circuit with control on both forward and back pressure

Fig. 25—Below—Forward and back pressure variations due to changes in work load for the locked circuit of Fig. 24



This circuit is used to illustrate the fact that forward pressure control on a variable-delivery circuit can be used. The circuit itself has little practical importance because the circuit in *Fig.* 21 will perform equally well at higher efficiency without the use of an expensive high pressure make-up pump.

Variable-Delivery Circuit with Forward and Back Pressure Control: However, with the addition of a differential pressure regulating valve, the "locked" circuit, which has many advantages, is obtained. *Fig.* 24 shows this circuit. In principle, the circuit operates in the same manner as that shown in *Fig.* 9 of the first article (M. D., April, 1946). The pressure characteristics are depicted in *Fig.* 25 and are identical with those shown in *Fig.* 10 of the first article, Equations 8, 9 and 10 being applicable to the "locked" circuit.

Advantages of controlling both forward and back pressure in a circuit were not discussed in the earlier article. In any hydraulic circuit a rapid fluctuation of load will result in a compression or an expansion of the controlling columns of fluid. In the circuits shown the controlling columns are in either the forward or back pressure cylinders, or both. They compress and expand in somewhat the same manner as a steel specimen, the Young's modulus for ordinary hydraulic oils being approximately 238,000 psi. Therefore the change in pressure, ΔP, when an expansion or compression takes place on a column of constant area is given by the equation

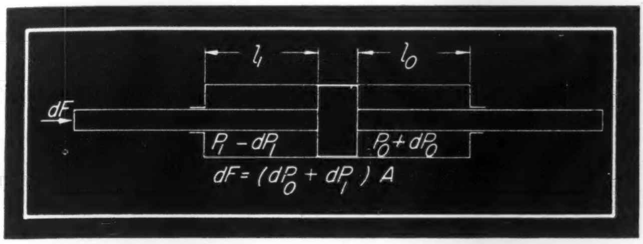
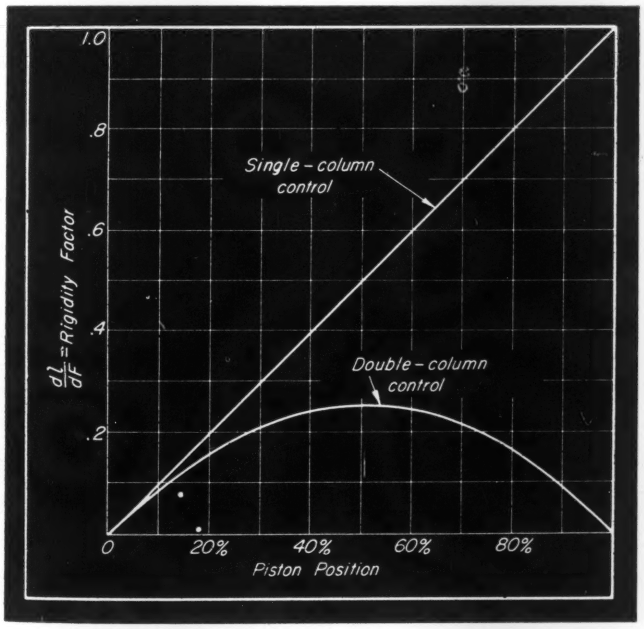


Fig. 26—Above—Relation between load and pressure changes with controlled forward and back pressures

Fig. 27—Below—Comparison of "rigidity" of oil-filled cylinders with single and double column pressure control



$$\Delta P = 238{,}000 \frac{\Delta l}{l} \qquad (15)$$

where Δl = change in length, l = length of column, and ΔP = change in pressure, psi. This equation is analogous to the familiar spring formula

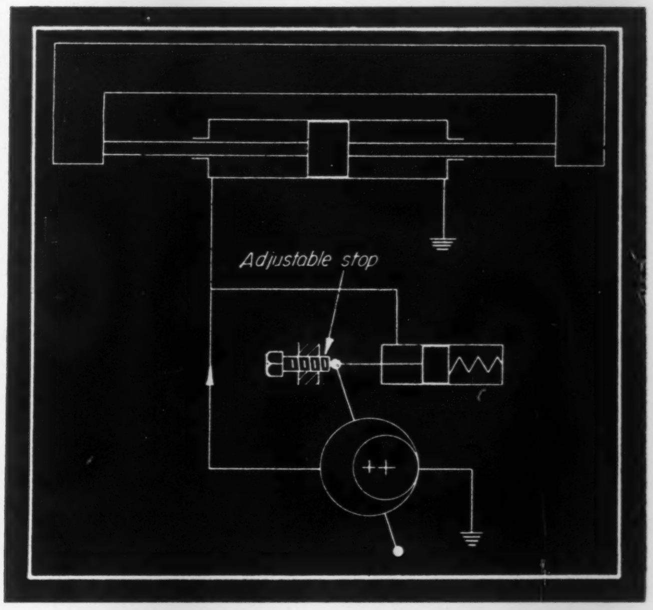


Fig. 28—Accumulator type variable-delivery pump circuit in which delivery decreases as load increases

$$\Delta F = K\ \Delta x \qquad (16)$$

where Δx = spring deflection, ΔF = force change, and K = spring constant where only one column is controlled, Equation 15 can be transformed to

$$\frac{dl}{dF} = \frac{l}{K} \qquad (17)$$

In double column control, *Fig.* 26, the equation for the rate of change of movement with respect to force would be,

$$\frac{dl}{dF} = \frac{1}{K}\ \frac{l_1 l_0}{l_1 + l_0} \qquad (18)$$

In *Fig.* 27 is shown a comparison of the performance of a system with single column control with one in which both columns are controlled. It will be noted that the rigidity at mid-stroke of the double column control is twice that of the single column control. The contained volume of the conduits will add a small constant to these values. Usually the effect of the conduit volume is negligible when compared to cylinder volumes.

ACCUMULATOR TYPE VARIABLE-DELIVERY CIRCUIT: The "accumulator" type of circuit derives its name from the characteristic which varies the delivery to suit the needs of the system. As the work resistance increases, the delivery decreases. *Fig.* 28 shows schematically a circuit in which the forward pressure acts on a piston in opposition to a spring. This piston and spring control the variable-delivery mechanism. The spring setting determines the maximum pressure, while an adjustable stop can be used to control maximum delivery.

This circuit has application on presses where it is desir-

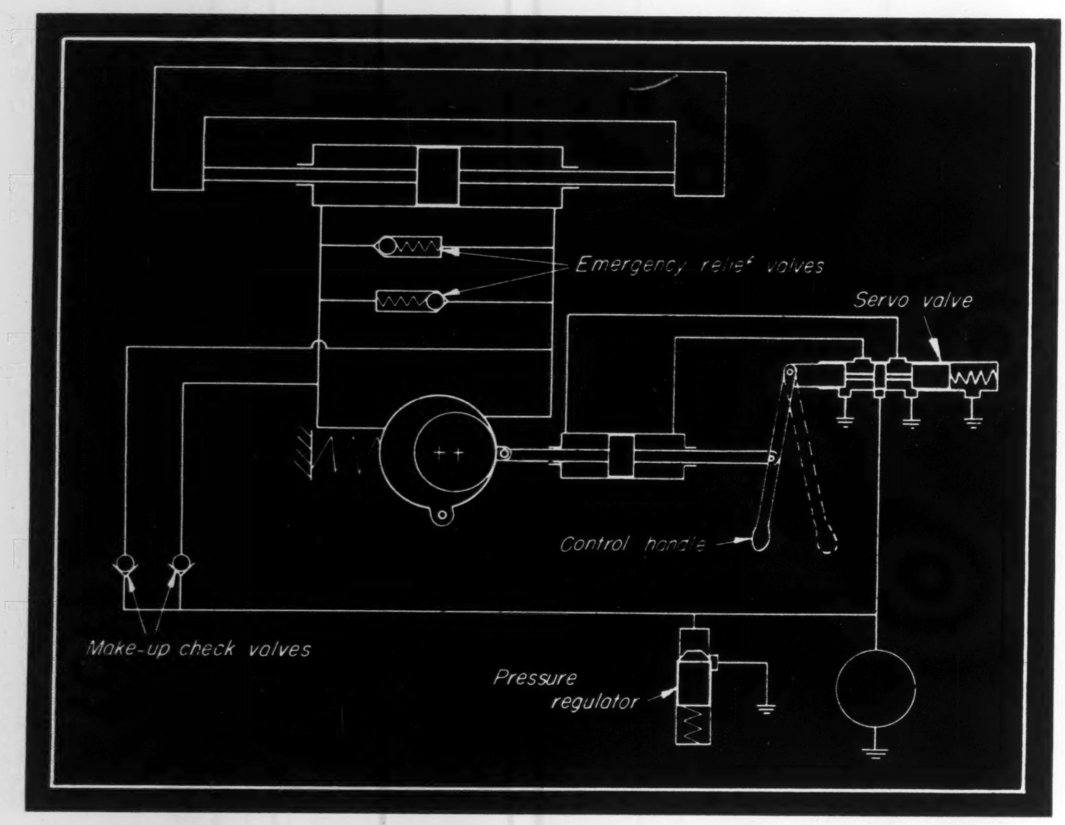


Fig. 29 — Variable-delivery pump control by servo, with feed-back connections. Similar circuit is used for tank turret traverse control

able to have a drop in velocity and rise in pressure during the working part of the stroke.

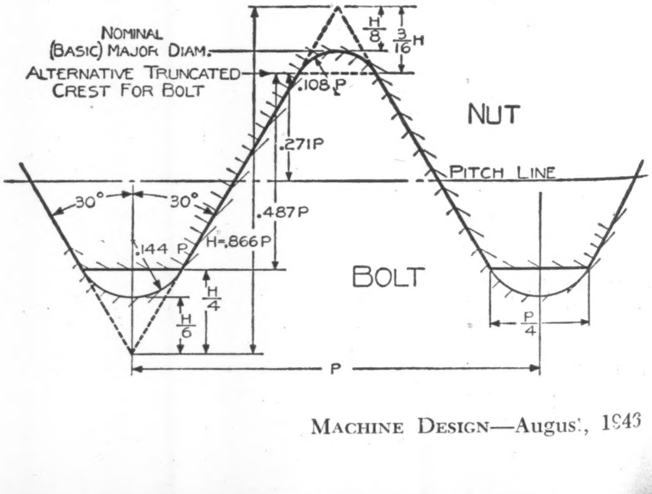
Servo-Controlled Variable-Delivery Circuit: In the circuit shown in *Fig.* 29 the variable-delivery mechanism is controlled by a servo. This circuit is really a velocity servo control rather than a servo position control in the usual sense in which the term is used.

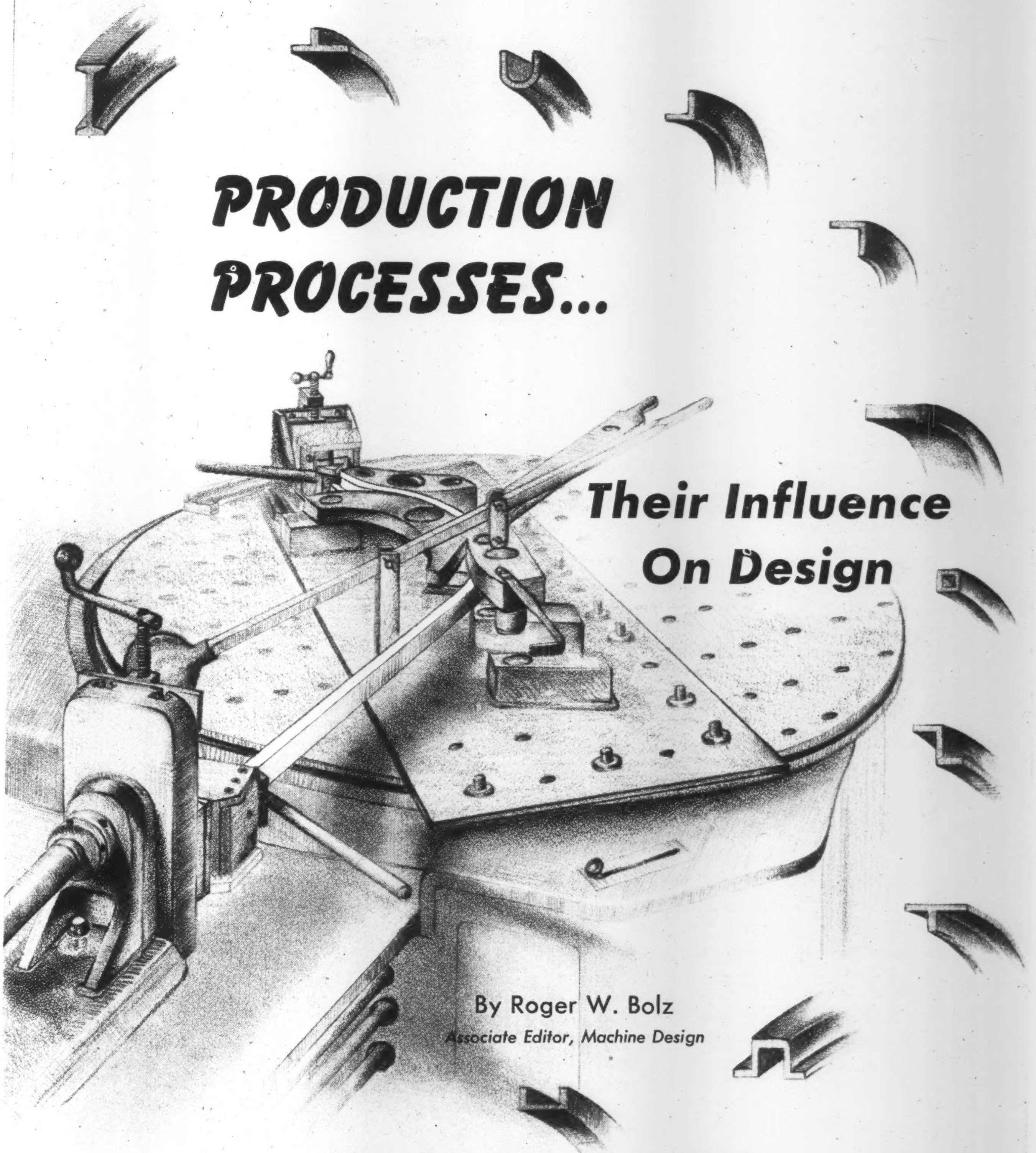
Hand control displaces the servo valve, causing a pressure unbalance on the piston which controls the pump displacement. As the piston moves to a new position, the servo valve is brought back to neutral by a feed-back linkage shown, for simplicity, diagrammatically. Thus the force required to change the flow from the pump by movement of the handle is only that required to slide the valve. An emergency relief valve safeguards the system from overload. A circuit based on this principle was utilized during the war for the traverse control of gun turrets on tanks.

In the next article of this series special valves and the design of circuits to use them will be discussed.

New Screw-Thread Form Proposed

Threaded parts made to the proposed new screw-thread form shown in the accompanying sketch would be interchangeable on a practical basis with those having the same nominal diameter and pitch made to the present American standard. Proposed by the Conference on Unification of Engineering Standards, which included representatives from the United States, Canada and Great Britain, the new thread form is the result of efforts to retain the best features of existing forms, particularly the American standard and the Whitworth threads. The proposed change would involve the minimum departure from existing practice consistent with the object in view—a common standard for general-purpose threads. As the sketch shows, the included angle of thread is 60 degrees, the same as the American standard (the Whitworth thread is 55 degrees), while the root radius approximates that of the Whitworth. Minor diameter of the nut is truncated like the American standard, while the major diameter of the bolt may be either rounded or truncated at the option of the user.





PRODUCTION PROCESSES...

Their Influence On Design

By Roger W. Bolz

Associate Editor, Machine Design

Part XIV–Section Contour Bending

CONTOUR forming of metal sections, a processing method given great impetus by production requirements of World War II, developed from a humble beginning on machines designed primarily for the forming of piping. Simple bending operations as performed on tubular cross sections involve, essentially, little more than the application of a bending moment at the desired point. Contour forming as it is known today

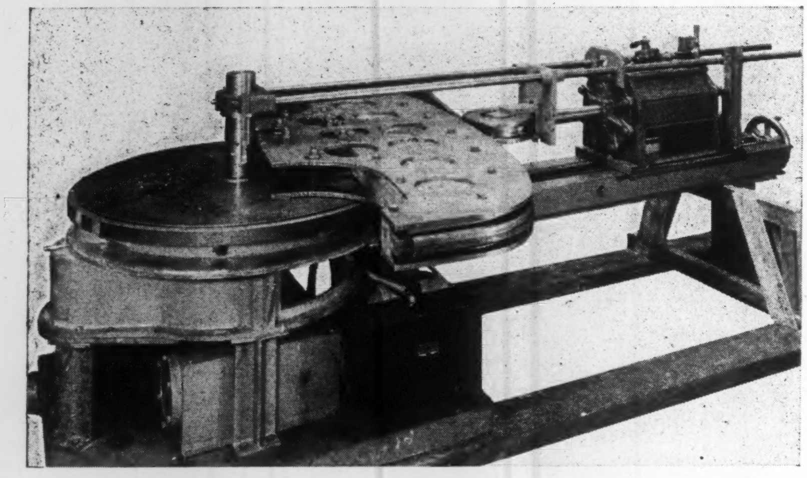
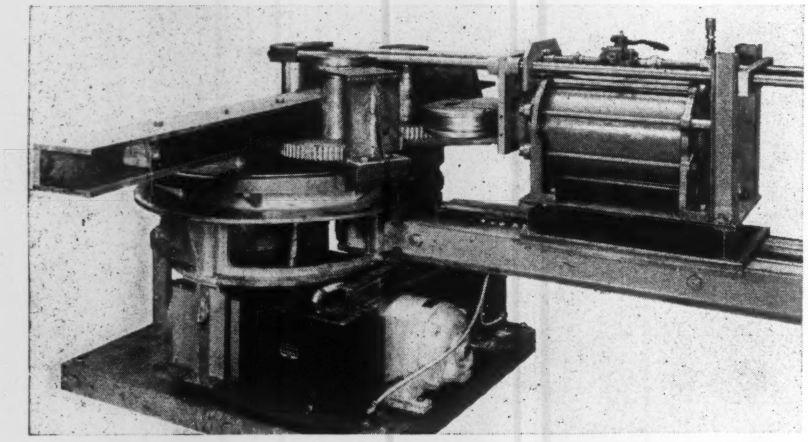


Fig. 1—Above—Draw-bending machine fitted with a special profile attachment for the bending of sections

Fig. 2—Below—Multiple-purpose roll-bending machine equipped with a profile attachment for long section forming



covers the reforming of metal sections of all types—roll-formed sections, shapes, extrusions, etc.—normally received in straight lengths, into various contours.

Parts produced on bending machines start with the simplest forms of bent tubing and piping for an infinite variety of uses including machine frames, vehicle and aircraft fuselages, and lines for transmission of fluids. Recent production of complex sections with compound curves includes refrigerator cabinets, automobile bumpers, aircraft door frames, wing parts, gun-turret rings, jet-engine parts, railway-car parts, decorative trim moldings, etc.

Since the bending moment needed for the forming of sections can be applied in a great many ways, there is a wide variety of machines available to achieve these ends. Classified generally, these methods are as follows:

1. Draw
2. Roll
3. Ram
4. Compression
5. Stretch
6. Compression-stretch

Draw Machines: The so-called drawing process is accomplished on a machine having a rotating die, to which the piece being bent is clamped, and a roller, against which it is drawn, *Fig.* 1. The neutral axis lies between the center of the section and the inner fibers, with resultant thinning of the outer portions and slight thickening of the inner walls at bends. In general, the strength of such a bend is lower than that of an unbent portion. Flattening effect on these machines is severe where sections are not fully supported, consequently tubular sections require an internal mandrel.

Design of mandrels for tubular sections is subject to infinite variation—plug, shaped, ball, and "snake" mandrels being the most common. These mechanical mandrels, however, are often difficult to set up and lubricate and in some cases require special means for withdrawal. To offset these difficulties and eliminate the 5 per cent or greater flattening effect at bends, a liquid or hydraulic mandrel is used. Flattening is eliminated entirely and bending limits are governed largely by the "wrinkle point" of metals.

The draw machine is especially suited to contouring thin-wall tubing and similar sections to close radii in production and is frequently used for other sections. Power required for operation of draw machines is the lowest of all the types. Pipe from ½-inch to 10-inch maximum can be handled in such machines.

Roll Machines: The simplest roll machine comprises a pyramid of rolls, one of which is adjustable with respect to the other two. A section to be bent is passed through the rolls which, acting somewhat like a small rolling mill, produce the desired curve or radius on the piece. Rings or continuous coils may be produced and, since there are no dies, a variety of radii may be had with only a simple adjustment of the rolls.

Although power consumption is about four times that of the draw machine, loading and unloading operations are relatively more simple. In addition, much more accurate bends may be had, with little or no flattening or wrinkling, on a wide variety of materials as long as the radius of bend is not less than three times the diameter of the driving roll.

Fig. 3—Below—Compression-forming machine for the bending of heavy pipe by means of a rotating roll arm

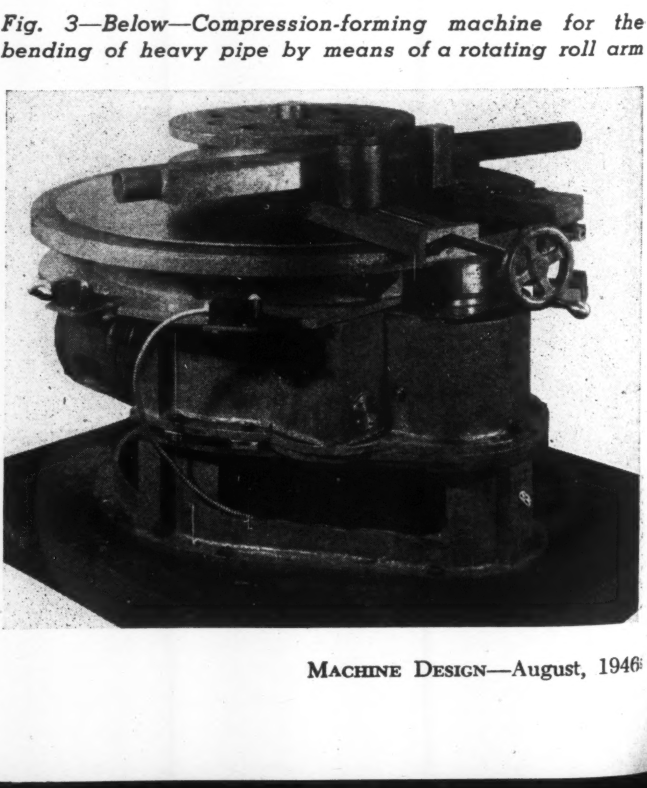
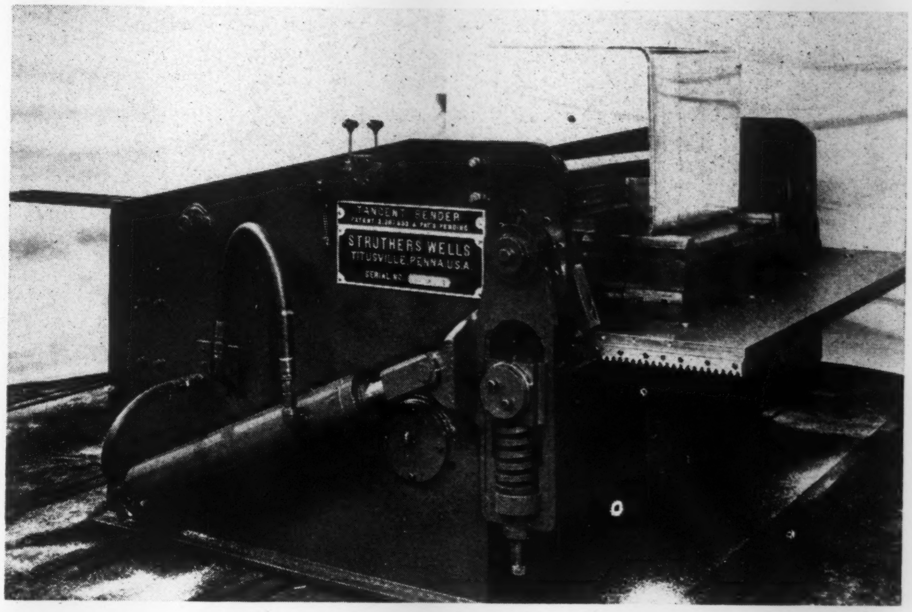


Fig. 4—Right—Compression tangent bender utilizes a rocking die-plate to edge bend deep flanged sheet shapes without wrinkling



Production rate is low and cost per piece relatively high on most machines since they are massive and slow.

An adaptation of the roll machine is often used as an adjunct to the roll-forming process of producing sections[*] and as such offers many economies where bends are suitable. An interesting machine combining the features of the roll, draw and compression machines is shown in *Fig.* 2. On the turntable is mounted a bending arm and stop arm, each of which is equipped with an adjustable roll. On the central spindle is mounted a suitable die. Draw bending can be accomplished by holding the arms stationary and actuating the central spindle and die; roll bending by rotating the rolls; and compression bending by holding the central spindle and die stationary and rotating the roll arm. This arrangement is used to roll thin-wall tube to the allowable radius and then, without change in set-up, die bend it to a close radius without a mandrel. Also, the rolls may be used as a source of power to handle a long straight die with a compound curved insert, *Fig.* 2, to produce a long-radius catenary where the pieces are exceptionally long. In general, the roll machine can handle shapes up to 6-inch angles but is unsuited to multi-plane or compound profile work.

Simulates Stamping

RAM MACHINES: A ram bender consists of two supports for the section to be bent and a central die operated by a hydraulic cylinder for applying the load. Simulating the action of the common stamping press, the ram machine is used for bends on extremely heavy sections such as pipe up to 14-inch diameter, railroad rails, reinforcing bars, structural sections, etc. Accuracy is poor and production low, making such machines suitable more for maintenance work. The principle of ram bending, however, is utilized in other units.

COMPRESSION MACHINES: As previously indicated, the compression process utilizes a stationary die onto which the part to be formed is held while a rotating arm wipes the piece into the die contour, *Fig.* 3. Similarly, the single-wing tangent bender utilizes a rocking die plate to wipe the shape onto the master die, *Fig.* 4. Still another version utilizes a sta-

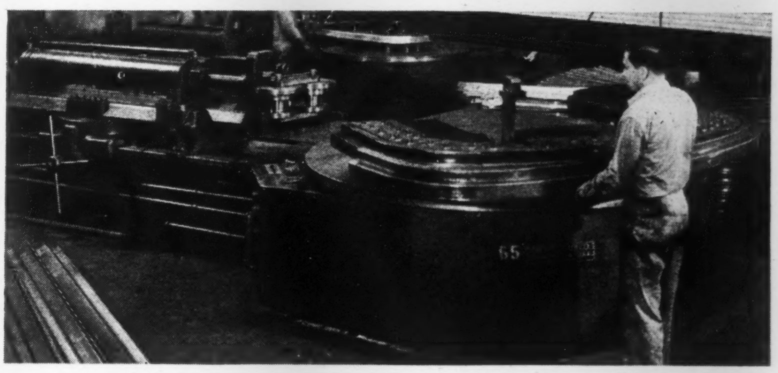
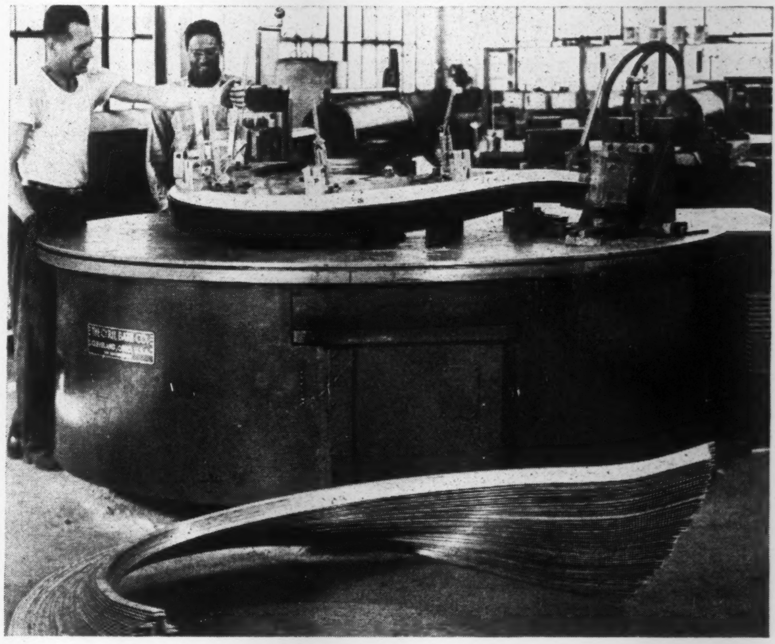


Fig. 5—Above—Production compression machine for contour bending heavy steel nose ribs for trailers

Fig. 6—Below—Aluminum alloy Z formed on a stretch machine with three radii in the horizontal plane and five in the vertical



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[*] See "Part X—Roll Forming" of this series, MACHINE DESIGN, April, 1946.

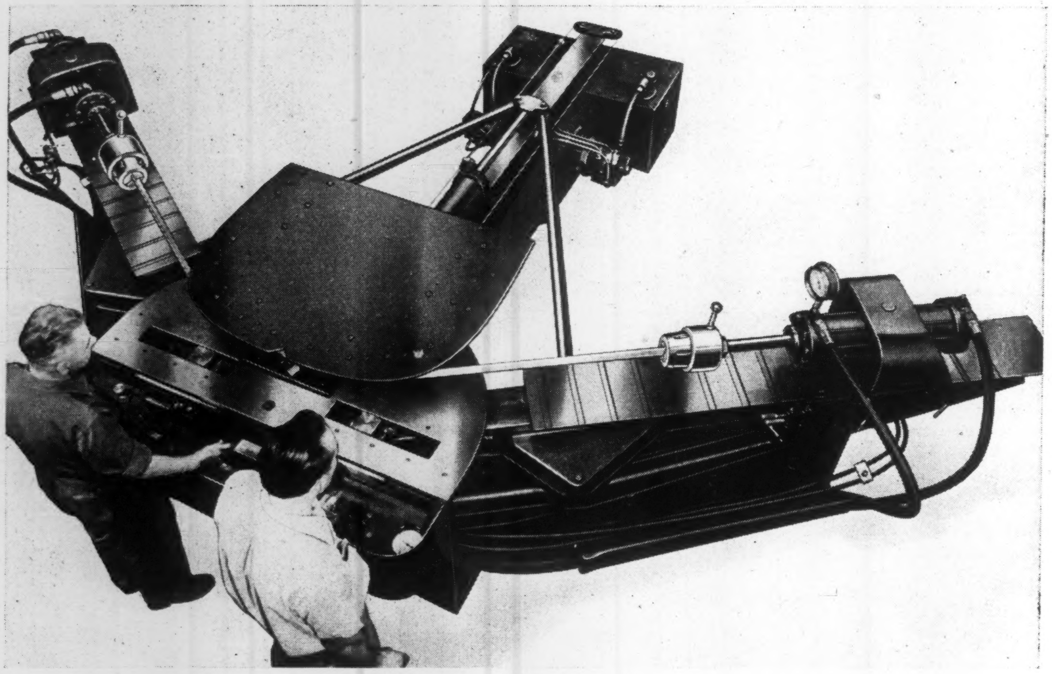
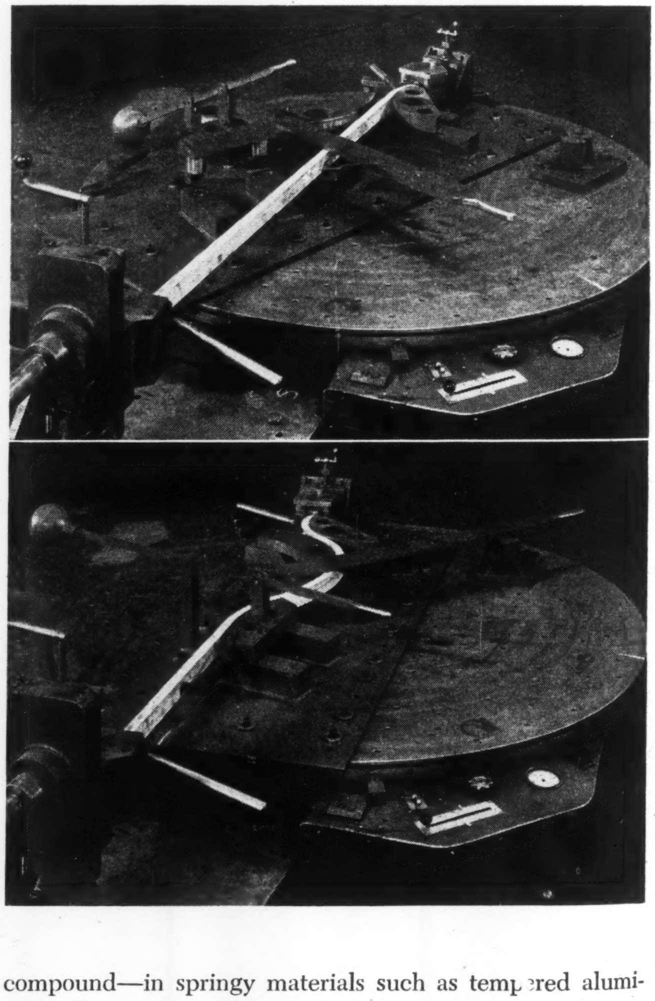


Fig. 7—Left—Stretch machine for forming uniform contours on sections and extrusions. Stretch set is induced after contouring

Fig. 8—Below—Severe reverse bends for this aluminum channel section necessitate reversals in table rotation during stretch-forming process



tionary arm and a moving die table, *Fig.* 5. Shoes, rolls or tangent dies mounted on the main ram of these machines are used to force the material into the die contour.

Compression forming results in a bend the neutral axis of which is between the center and the outer fibers of the section. Thus the inner wall or, in some cases, flange is somewhat heavier and the outer wall substantially the same as the original which, with the action of cold working, results in a bend stronger than the unbent section. Owing to this minor stretching of the outer wall, chromium-plated sections can be formed to generous radii without damage to the plating. The same is true for nickel-plated and enameled parts.

Compression forming methods are highly satisfactory where bends are severe and heavy sections must be controlled, and also where metal must be formed to small radii or sharp offsets. Since mandrels are not generally employed on compression machines, thin-wall tube sections are seldom handled.

Springback Sometimes a Problem

Except on extremely ductile or workable materials, the ironing methods of compression forming often fail to reach the elastic limit of the material being formed. Consequently, compensation must be made in the dies to allow for springback. This problem of springback with materials having good elongation characteristics is easily overcome by resorting to the stretching method.

Stretch Machines: Although not nearly as fast in production as compression forming, the stretch method overcomes the internal strains of prior cold working by stretching a section of metal to its elastic limit during forming. Held in special gripping jaws, the piece is first stretched to approximately its elastic limit and, with constant tension, is then laid onto the die form, *Fig.* 6. Another type machine without a rotating table and somewhat more limited is shown in *Fig.* 7.

Many combinations of curves are possible—constant radii, varying radii, single-plane or multiplane, simple or compound—in springy materials such as tempered aluminum alloys and stainless steels with part-to-part uniformity and negligible springback. Complicated reverse curves, of course, make for slower production, *Fig.* 8.

Compression-Stretch Machines: Where the elongation characteristics of a specified material are insufficient to withstand the severity of stretch forming, a combination of stretch and compression can be resorted to for maintaining uniformity and obviating excessive springback. The hat section shown in *Fig.* 9 required such a combination. Pressure forming on a machine such as that in *Fig.* 5 retained the section shape—the outer flange fibers stretching about 6⅞ inches over the original 36-inch length and the inner fibers compressing about 5⅛ inches. Long, difficult hollow-section forming, such as with rectangular tubes, also requires the combination method.

As noted previously, the so-called tangent bending process, which utilizes a rocking die to avoid the surface abrasion often present with confining rolls, also has been designed to include stretching, *Fig.* 10. A flanged sheet inserted between the dies is first stretched to crown the top and then carried around to form the sides, *Fig.* 11. Deep flanges on the parts are controlled to avoid buckling which normally would occur during simultaneous stretching of outer areas and compression of inner areas and flanges. Flanged sheets up to 42 inches wide with radii up to 6 inches can be handled in double-wing machines and up to 120 inches wide with radii up to 8 inches in single-wing machines.

Deeply curved heavy-gage parts such as automotive bumpers, roof trusses, etc., which require a controlled combination compression-stretch technique can also be handled on certain types of tangent bending machines.

Since all the bending techniques, excepting the roll method, necessitate the use of dies, it is usually more economical to hand form where quantities run less than 100 pieces. Most efficient quantities on universal machines run from 1000 to 100,000 pieces. Where tremendous quantities are required, a specialized machine can handle large parts up to 120 per hour. On simple bends on 1-inch tube, a special compression bender handling ten at a time produces over 1000 pieces per hour.

Design: Inasmuch as all but the roll method require dies, the subject of dies is highly important. Dies for most light compression and stretching work can be made of Kirksite, Formite, Masonite or similar material. Heavy forming, however, requires adequate dies with the contour radii properly designed to obviate springback discrepancies unless stretching is used. To account for normal springback, radii must be reduced by the following amounts:*

Aluminum (Soft)	3%
Copper (Soft)	3%
Mild Steel	5%
Stainless Steel (Annealed)	5%
Aluminum Alloy (S. O. Temper)	7%
Chromium-Molybdenum Steel (Hard)	10%
Stainless Steel (Hard)	10%
Aluminum Alloy (S. T. Temper)	12%

Standard minimum bend radii (to center of bend) for tubing are usually determined by the formula 0.775 $(D^2 - d^2)/g$, where D is the outside diameter, d is the inside diameter, and g is the wall thickness. Mandrel bends can be smaller but of course involve considerably greater production costs.

Radii Limited by Roll Diameter

In the design of contours, sections which require sharp or deep offsets naturally require consideration of the diameter of the rolls used in compression forming. Radii must be generous to allow for easy traverse of reverse bends.

Where holes are to be punched prior to forming, the stretch method generally cannot be used owing to distortion of the holes. In such cases design should be con-

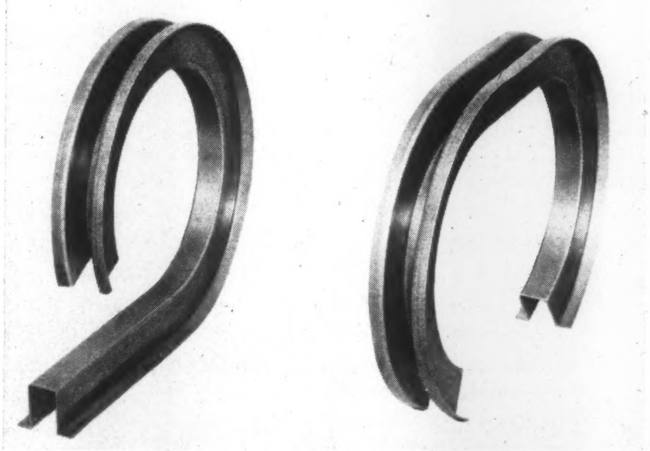


Fig. 9— Above — Heavy steel hat section formed by compression-stretch

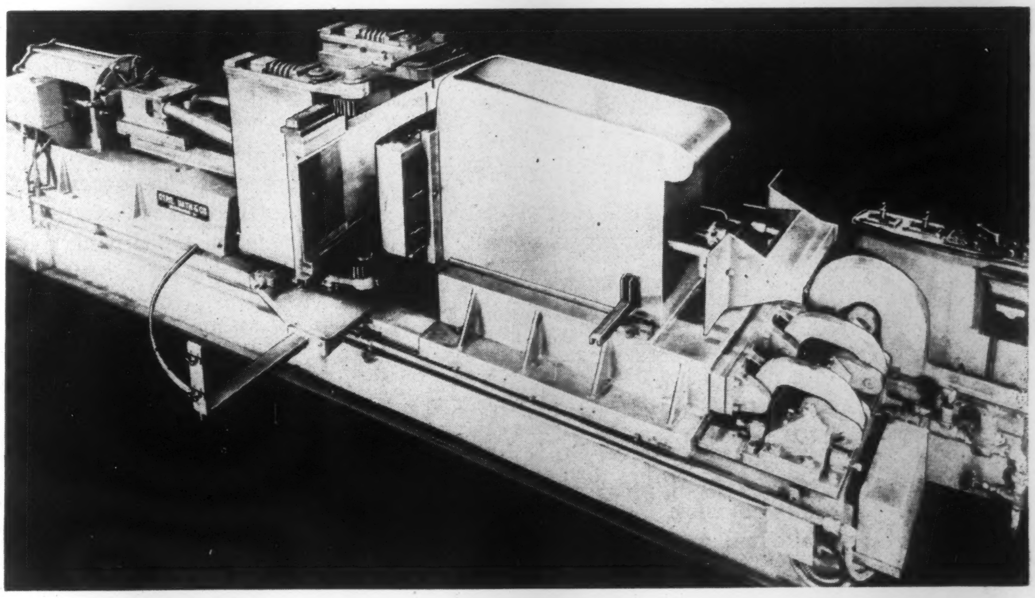


Fig. 10 — Right — Double-wing tangent compression-stretch bending machine primarily designed for radius forming flanged sheet into cabinets

sidered for the compression process only.

Preformed flanged sheet contoured with flanges out are usually stretch formed to shape. With about 0.036-inch sheet having ⅝-inch flanges, ½-inch radii inside bend can be produced on a tangent bender. If flange width is ⅞-inch, a ¾-inch radius can be formed. With 0.060-inch sheet having a 1-inch flange, the minimum radius is also ¾-inch. In each case flange width is reduced approximately 3/16-inch after stretching.

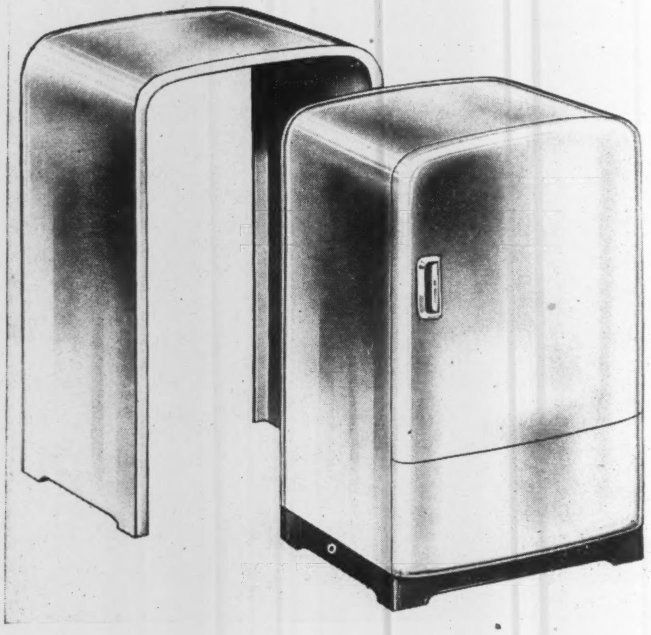
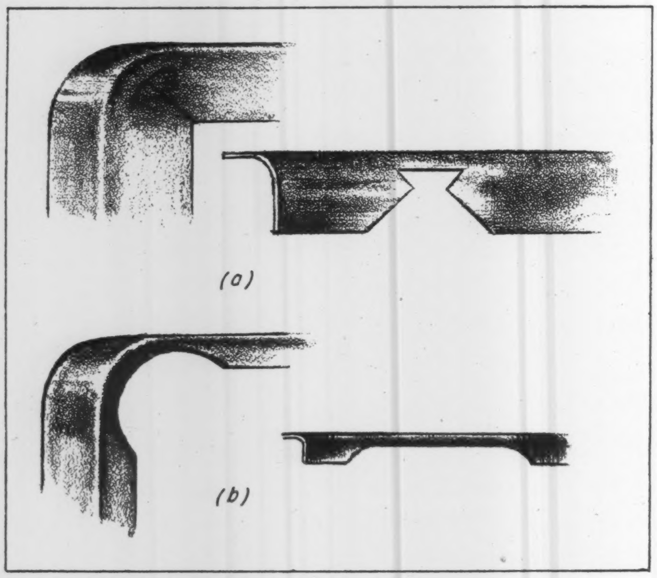


Fig. 11—Above—Refrigerator outer shell formed from flanged sheet on a double-wing tangent bender

Fig. 12—Below—Where exceptionally wide flanges are required, design at (a) is recommended for welding, and design at (b) where welding is not necessary or where the finished notch must be open



Flanged sheet preformed with flanges from ½-inch to 1½-inch wide and inside radii of 3/16 to ¼-inch can be tangent bent with outside contour radii from 1 inch to 6 inches respectively. Flanges are compressed or upset when bent inward and consequently the overall width remains the same.

For exceptionally wide flanges which must be welded, a design as shown at *a* in *Fig.* 12 is recommmended. Welding, grinding and polishing are then confined to flat surfaces only. Where welding is not necessary, design as shown at *b* in *Fig.* 12 is recommended.

MATERIALS: In general the various techniques of bending require a high ductility metal for maximum economy. Where semiductile materials must be used, the compression or compression-stretch methods are usually necessary to squeeze the material into the new shape. Shapes of 24ST aluminum alloy, hard-drawn shapes of Monel K with a ductility of 2 per cent, and hard-drawn copper bar stock have been bent successfully by these methods.

With long, shallow bends in soft materials, stretch forming produces the most accurate, constant results. Likewise high-alloy aluminum, stainless steel, etc., usually require stretching to achieve uniformity. Low-alloy carbon steels, aluminum, stainless steel, etc., would probably be relegated to the compression method for higher output.

TOLERANCES: As in all other work, the closer the tolerances the greater the cost in time, tooling, etc. As indicated previously, the stretch method is subject to the least effect from springback and logically can be relied upon to produce the most exacting results—dependent, of course, upon die accuracy—where material worked has adequate elongation characteristics. Although not as accurate in mass production from piece to piece owing to springback characteristics of materials, compression forming has a greater production rate.

Flattening Effect on Tubes

The compression machine produces a flattening effect of about 5 per cent on tubular cross sections unsupported by an internal mandrel, when the radius of bend is limited to a minimum of four times the diameter for 6-inch pipe, three diameters for 2 to 5-inch pipe, two diameters for ¾ to 2-inch pipe, and one diameter below ¾-inch. On tubing the minimum radius is about three diameters except for copper which may be appreciably smaller. Flattening effect with the draw process is about 7 per cent for the same limits but with a mandrel can be reduced to around 3 per cent. As previously mentioned, a liquid mandrel offers no flattening effect within the above limits, wrinkling being the critical factor. No wrinkling and negligible flattening effect are experienced on the roll machine if the radius of bend is limited to a minimum of three times the diameter of the driving roll.

If the end of a bent tube must be maintained square without extra trimming, the length of straight end beyond the point of tangency with the bend must be at least equal to the diameter plus 0.01 times the radius of the bend.

Collaboration of the following organizations in the preparation of this article is acknowledged with much appreciation:

Cyril Bath Co. (*Figs.* 5, 6, 8, 9, and 10)	Cleveland
Goodyear Aircraft Corp.	Akron
Hufford Mfg. Co. (*Fig.* 7)	Los Angeles
Pedrick Tool and Machine Co. (*Figs.* 1, 2, and 3)	Philadelphia
Republic Steel Corp.	Cleveland
Struthers-Wells Corp. (*Figs.* 4, 11, and 12)	Titusville, Pa.

Evaluating Self-Locking Nuts

Included are analyses of plain, jam and castellated nuts, nut and lock-washer combinations and nuts with built-in self-locking features

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ANY ORDINARY nut loosens when vibration is present due to the vibrational forces acting to relieve the frictional forces existing between the base of the nut and the abutting surface, *A*, and between the mating threads of the nut and bolt, *B*, *Fig.* 1. Whenever a nut is drawn against a seat, the axial pressure, *Y*, has a component $X = Y \sin \theta$ where θ is the helix angle of the threads. This component, *X*, acting in a direction parallel to the inclination of the thread, tends to turn the nut off the bolt. In a static application, this turning is resisted by the frictional forces that act on all the contact surfaces, but if the frictional forces are themselves lessened or removed by dynamic forces, then it may be possible for component *X* to cause the nut to rotate off the bolt.

NUT AND LOCK-WASHER COMBINATION: Combination of a bolt, nut and lock washer is, of course, one of the most common types of fastenings. It generally is thought that the lock washer supplies an independent locking feature which prevents loosening of the nut on the bolt. Actually, the lock washer is useful only when the bolted connection might loosen because of relative dimensional change between the bolt length and the parts being held together by the bolt. This change might, for example, be caused by lengthening of the bolt due to creep, loss of resilience in the bolted members, difference in thermal expansion between the bolt and the bolted members, or wear at the contact surfaces. In such cases, all of which are static, the lock washer, by expanding, holds the nut under axial load and thus tends to keep the assembly tight.

However, relative dimensional change might also be caused by vibrational or dynamic forces. These forces have a great tendency to turn the nut and the lock washer does not prevent this. In laboratory tests it is found that the nut and lock-washer combination will loosen about as fast as an ordinary nut when tested on standard vibration equipment. In

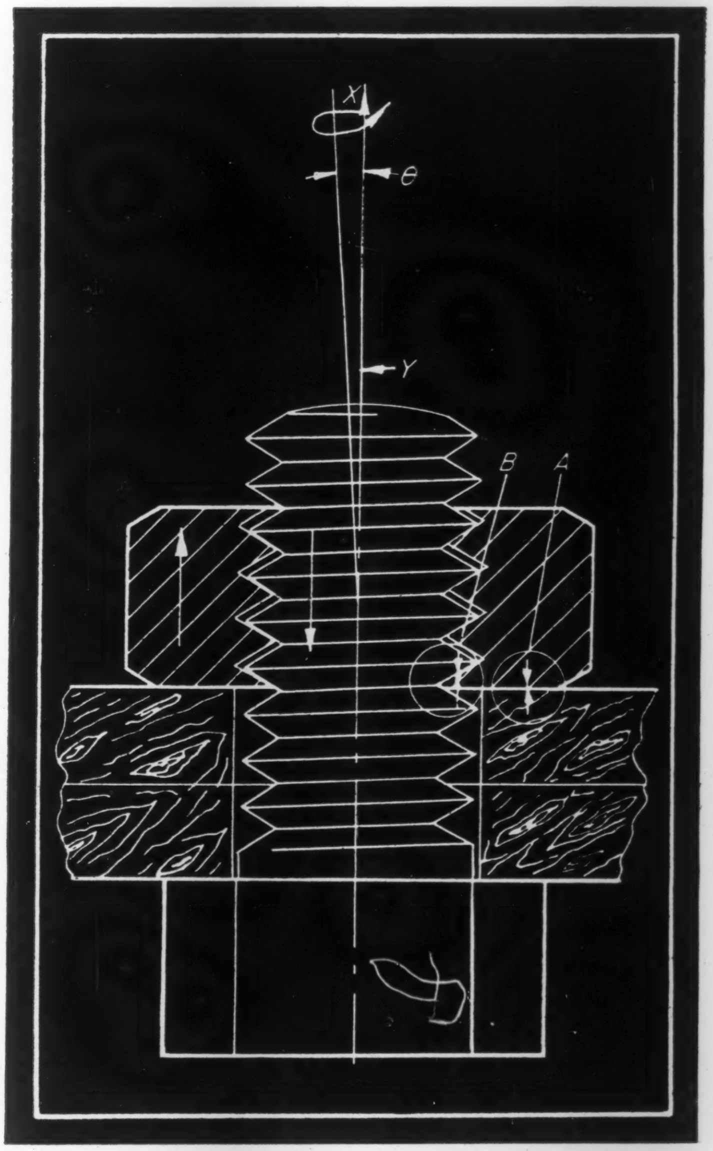

Fig. 1—Ordinary nut loosens when vibrational forces overcome frictional forces at A and B. Force X, a component of axial pressure Y, is loosening factor during vibration

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From a paper presented before the Machine Design Group at the recent semiannual meeting of The American Society of Mechanical Engineers, in Detroit.

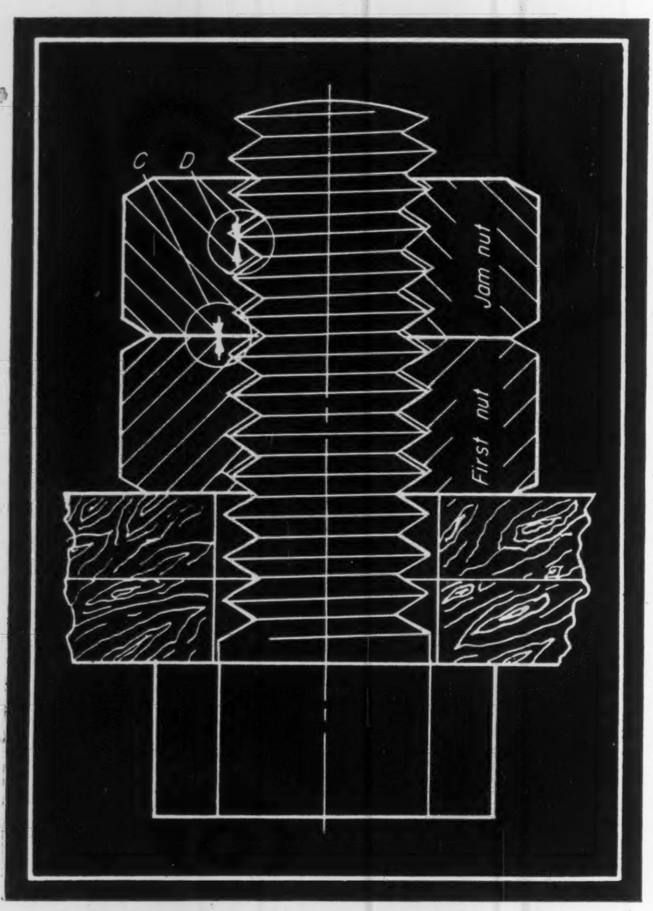


Fig. 2—Jam-nut assembly during initial stages of jam-nut tightening. Rotational resistance of first nut is improved by added frictional pressure effective at C and D

tests made in our laboratory, where the ordinary nut loosened in about eight seconds, the nut and lock washer combination loosened in about the same time. Tests were also made with a type of lock washer which employs serrated edges to increase the friction between the washer and the assembly surface, and loosening occurred in about fifteen seconds. This latter type has a further disadvantage, i.e., it mutilates the surface against which it is pressed.

Summarizing, lock washers are suitable for service under static conditions where re-use is not a factor, and where problems of relative dimensional change are to be overcome. However, their use should be avoided where vibratory conditions exist.

JAM NUTS: Another type of fastening device frequently used is the double nut assembly, with one nut functioning as a jam nut. As originally conceived, jam nuts were intended to hold their position by maintaining pressure against the thread flanks and the opposing nut faces, independent of load, sufficient to insure frictional resistance of any rotating forces. To perform this function properly the axial seat pressure of the second, or jam nut must be greater than that between the face of the first nut and the bolted surface. Tests in our laboratory showed that the second, or jam nut had to be tightened with a torque twice that used on the first nut, if the assembly was to fulfill its correct function. While this appears feasible, in practice the sequence of events followed by the mechanic applying the nuts usually produces an assembly which combines all the limitations of a nut dependent upon axial seat pressure with a few complications of its own.

Why Jam Nut Does Not Lock

As the jam nut is tightened against the first nut, *Fig.* 2, the rotational resistance of the first nut is increased by the frictional pressure between the opposing nut faces, and the extra thread friction of the jam nut. As this pressure is increased by further tightening, the axial load in the bolt is picked up by the threads in the jam nut (see *D*) and the pressure between the first nut threads and mating bolt threads is being simultaneously and proportionally reduced. The first nut threads are being pushed in a loosening direction, toward the bolt head and away from the upper flank contact on the bolt, by the progressive tightening of the jam nut.

As the jam nut is tightened further, its threads pick up the entire axial load in the assembly, and the first nut becomes merely a washer with threads, for all effective contact is lost between bolt threads and the first nut threads, *Fig.* 3. Thus is produced a nut assembly which is dependent on axial seat pressure, but which uses two nuts instead of one, the load from the first nut being transferred to the second, or upper nut. For all practical purposes, the original first nut becomes part of the assembly

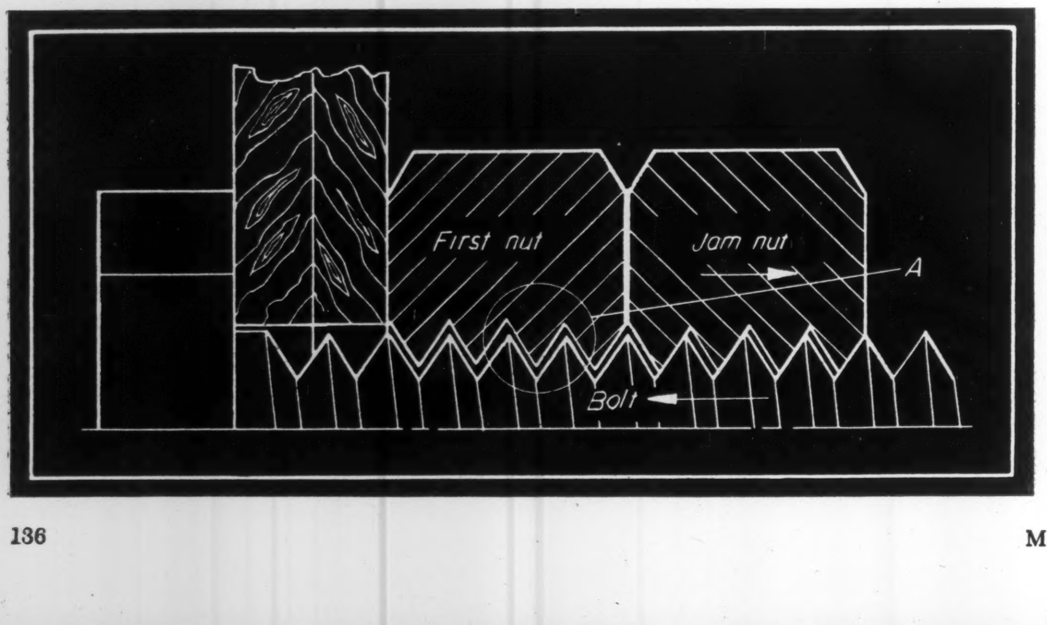


Fig. 3—Left—Why jam nut does not lock first nut. As bolted member is compressed, first nut threads lose contact with bolt threads and first nut becomes merely a threaded washer

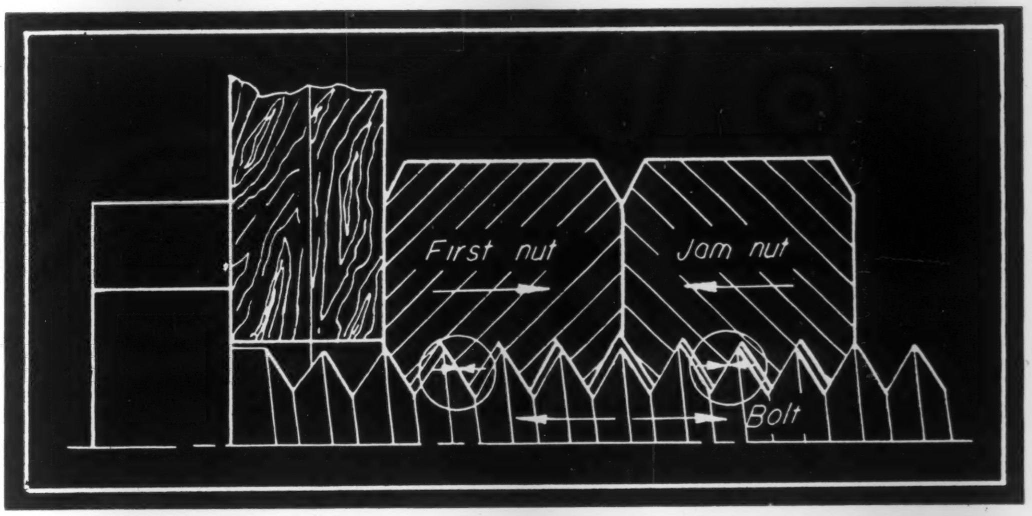


Fig. 4—If first nut and jam nut are tigthtened against each other, section of bolt between them is highly stressed and subject to failure under vibration

being held between the bolt head and the second, or jam nut.

If, as is sometimes done, the lower nut is turned with a second wrench counter to the direction of application of the first nut, and at the same time, the nuts no longer pull against the bolt head but against each other, *Fig.* 4, the portion of the bolt between the two nuts is highly stressed, and failure of the bolt under vibration may result at the mating plane of the two nuts due to concentration of stress in the bolt. For any given load value, to avoid this overstressed condition, the designer would be forced to use the next larger bolt diameter.

Subject to these human variables at the time of application, the jam nut assembly is further limited by the inability of the methods engineer to effect the labor economies inherent in installation of nuts with power wrenches on the assembly line.

Castellated or Slotted Nuts and Cotter Pins: One of the most widely used of the conventional locking fastenings is the castellated nut and cotter pin, *Fig.* 5. It is true that the cotter pin will prevent rotation of the nut, but in practice the diameter of the cotter pin is appreciably smaller than the hole in the bolt and the slot in the nut. Consequently, the nut can back off under vibration the same as any common nut, until these clearances are absorbed and the cotter pin cocks and jams the assembly.

Hazards Introduced by Vibration

Under conditions of severe vibration, the continuous intermittent impact of the nut corner on the cotter pin tends to shear the pin, and if this happens the nut is free to rotate. More serious, the broken pin may drop into a moving part and cause damage before its failure is apparent.

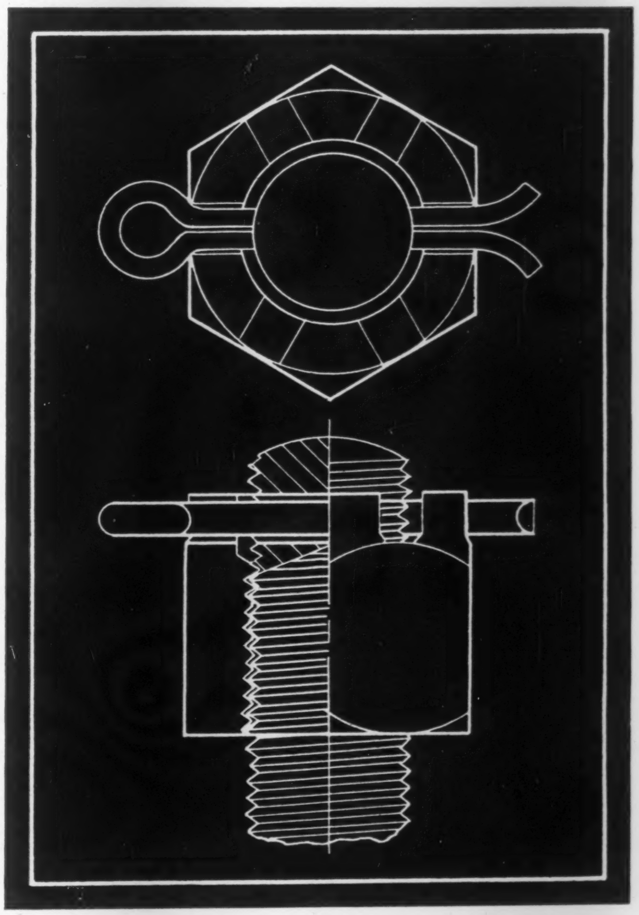
In practice, the use of predrilled bolts and castellated or slotted nuts increases the cost of an assembly or repair by the time required to align the bolt hole and nut slot, insert, and then clinch the cotter pin. Should the fastenings be in a relatively inaccessible location, this time factor becomes a major consideration. Similarly, the necessity for cottering the nut precludes the use of a power wrench or nut setter when the fastening is used in production.

Self-Locking Nuts: Most self-locking nuts available today may be classified into two groups on the basis of their locking principle, all nuts in each classification having the same limitations. The groups are those which:

1. Depend on axial pressure to maintain nut to bolt thread contact and thread friction
2. (*a*) Depend on radial pressure of metallic element to produce and maintain a clamping action on bolt threads
   (*b*) Depend on radial pressure of nonmetallic element to maintain a clamping action on bolt threads.

Nuts in the first group, dependent upon axial pressure,

Fig. 5—Castellated nut and cotter pin will lock only at definite positions. Also, intermittent impact of nut corner on cotter pin during vibration tends to shear pin

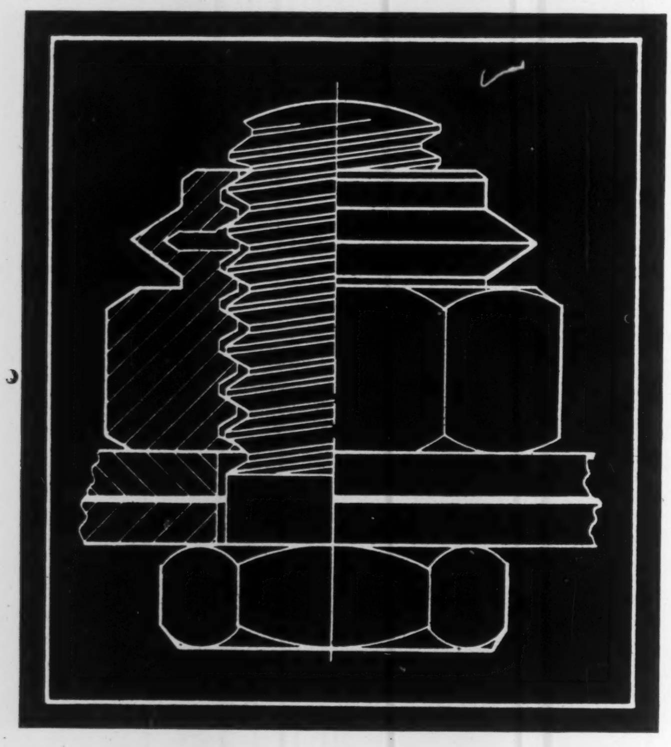


usually develop their locking characteristics by having two sets of threads out of phase with each other. In this type, *Fig.* 6, the locking effect is produced by setting the threads of the upper portion of the nut (or insert) out of phase with those of the main or load carrying section. Upon entrance of the bolt, the two sections of the nut are forced into phase (mating position) with resultant elastic deformation of the metal between the two sets of threads. The elastic tendency of this metal to return to its original position exerts an axial pressure on opposing flanks of the bolt threads, producing sufficient friction between the two to resist turning of the nut.

This design is subject to certain basic limitations: (1) When subject to vibration, there is a tendency for the two sets of threads to move momentarily into phase; during this instant there is nothing to prevent the nut from rotating on the bolt due to the ever-present rotational component of the axial load acting on the helix angle. (2) The amount of "out of phase" built into the nut must be carefully controlled if uniform locking characteristics are to be developed. Such careful control is not easily achieved in a low-cost, high-production item. (3) Metal fatigue in the elastically loaded section frequently results in fracture of the section at the point of highest stress concentration. (4) No protection is afforded the bolt threads against corrosion. (5) The high metal-to-metal pressure maintained by such a nut during its application or removal increases the tendency to gall the threads.

Nuts in group 2*a* depend on the radial pressure of a reduced metallic cross section to elastically maintain a clamping action on the bolt threads, as the reduced section is displaced radially by the passage of the bolt. This type, *Fig.* 7, is somewhat superior to the previous type, because radial pressure is independent of seat pressure and consequently less susceptible to the effects of vibration. Since steel has a relatively high modulus of elasticity, most designs of this type derive their locking action when the reduced pitch diameter of the two top threads, usually achieved by closing in the top portion of the nut blank, is forced radially outward by the bolt to its normal diameter.

Fig 6—Below—In this self-locking nut, threads at top are pre-set out of phase with threads in body of nut. When screwed onto bolt, threads at top of nut are forced into phase, creating frictional pressure on thread flanks



Principal service difficulty encountered in the use of nuts of this type is their inability to maintain uniform locking characteristics due to tolerance variations in commercial bolts. In industrial applications, commercial bolts are manufactured within standard bolt tolerances, yet vary so much within these tolerances that the locking portion of the nut threads will not fully engage the bolt threads. As a result, torque characteristics are erratic.

Nuts in the two foregoing classifications are all subject in some degree to two basic and serious limitations. They take a permanent "set" and lose an appreciable amount of locking torque after they are tightened. This is easily illustrated by measuring the prevailing locking torque and comparing it to the prevailing off torque once the nut is free from its seat. Secondly, being all-metal, they will, unless specially treated, rust and freeze to the bolt when exposed to the weather.

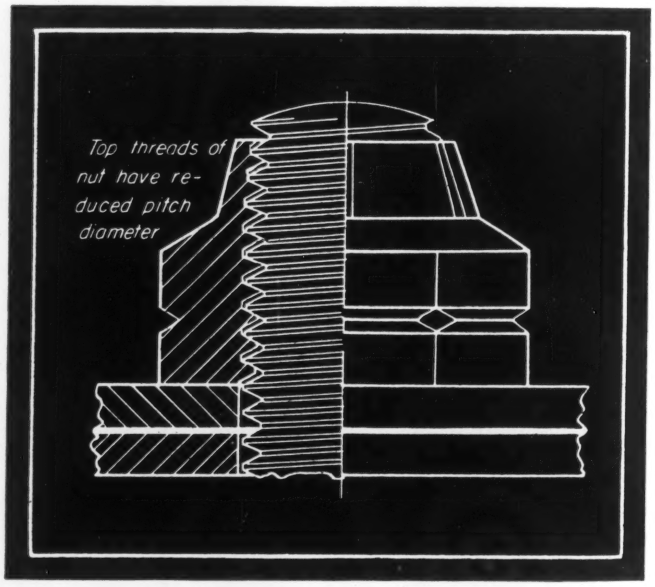


Fig. 7—Top threads of this self-locking nut are manufactured to a reduced pitch diameter. Thus, during assembly, they clamp the threads of the bolt

Nuts in group 2*b* incorporate most of the advantages of the other types without possessing their disadvantages. They can, by reason of their inherently elastic locking insert, adapt themselves to wide variations in bolt diameters while maintaining a uniform locking torque. Their nonmetallic elastic locking medium is independent of bolt loading and seals the bolt threads against the entrance of external moisture or leakage of internal pressure or liquids. Further, the soft, nonmetallic locking insert eliminates galling of bolt threads and plating.

Principal limitation to the application of the nonmetallic-insert type of nut is the inability of the insert to maintain its elasticity and locking characteristics at elevated temperatures.

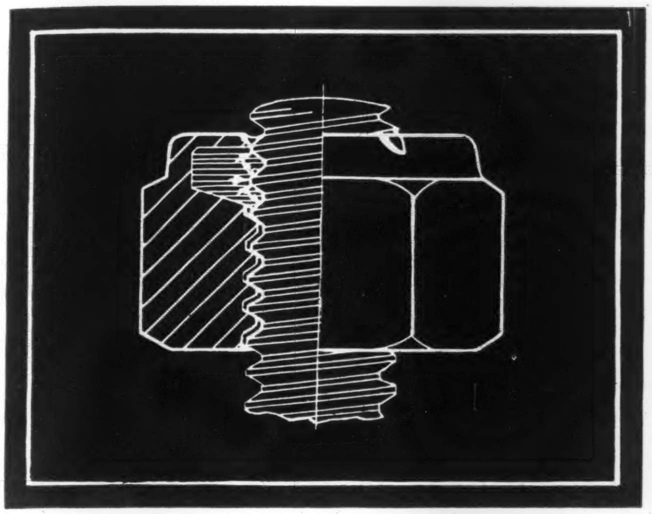


Fig. 8—Nonmetallic-insert type of self-locking nut guards against loosening and seals against moisture leakage. However, they should not be used at high temperatures

During the war it became necessary to establish a specification which would define the performance requirements of self-locking nuts in terms of present-day technology. The Army-Navy Aeronautical Specification AN-N-5 established the performance standards for self-locking nuts on military aircraft. Minimum requirements for locking torque, vibration, resistance and galling characteristics are specified in addition to the usual requirements for workmanship, material, thread fit, finish and dimensions imposed on a conventional nut.

From the standpoint of the general designer, no specifications exist in the files of the various technical societies detailing the performance requirements a self-locking nut must meet. The interested engineer has a choice of reviewing the AN aircraft standards and relating them to his problem, or developing his own standards, the latter being the more desirable. In this way, proper consideration could be given to any special requirements peculiar to that organization's fastening problem, and conflicting claims made for various nuts could be resolved on a common plane. Recognizing the limitations of a particular style of nut as previously outlined, a series of simple standard tests and qualifications would be established to enable the user to select the bolt and nut combination best suited to his particular application. Recommended tests include:

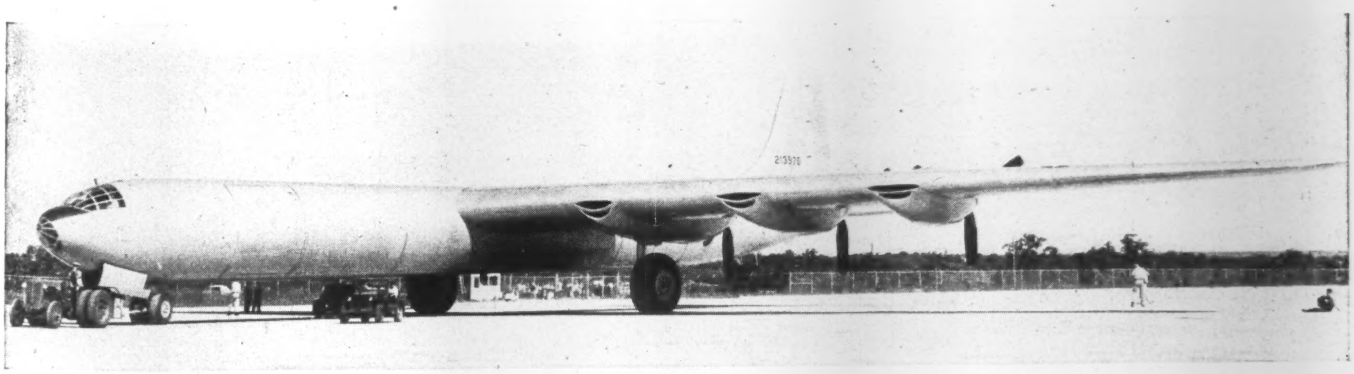
1. Vibration test
2. Installation and removal test
3. Repeated application under load
4. Wear and plating tests
5. Tests for special characteristics.

Information necessary to develop detailed test procedure may be obtained from the leading manufacturers of self-locking nuts or reference may be made to the aircraft specifications. It is the tests for special characteristics that call for the greatest amount of engineering judgment. The nuts in question should be studied to determine whether or not they possess any special features which may be of advantage in the particular application involved. Effects of humidity, or atmospheric corrosion often are neglected and the designer finds that after a period of service the fastener cannot be disassembled due to rusting of threads. Similarly, where the service temperature is beyond the normal capability of the locking device used, that fact should be given consideration.

XB-36 Ready For Tests

CONSTRUCTION of the world's largest land-based bomber, the XB-36, has been completed at the Fort Worth plant of Consolidated-Vultee Aircraft Corp. and a five to six weeks' ground test program is under way. Initial flights of the plane are not scheduled until late summer, the date depending upon the progress of ground and taxi tests.

Upon completion of the tests the new airplane will be assigned to the Strategic Air Command, which has the responsibility of planning and executing all AAF commitments requiring long-range and heavy bombers. The XB-36, designed and constructed under the supervision of the Air Materiel Command, is powered by six Pratt and Whitney 3000-horsepower engines. Designed early in the war for cross-ocean bombing missions in the event Germany took over all Europe, the plane has a wing spread of 230 feet and a fuselage length of 163 feet. Pusher type propellers are set into the after part of the wing. The crew of the XB-36, 15 in number, is accommodated in pressurized compartments.



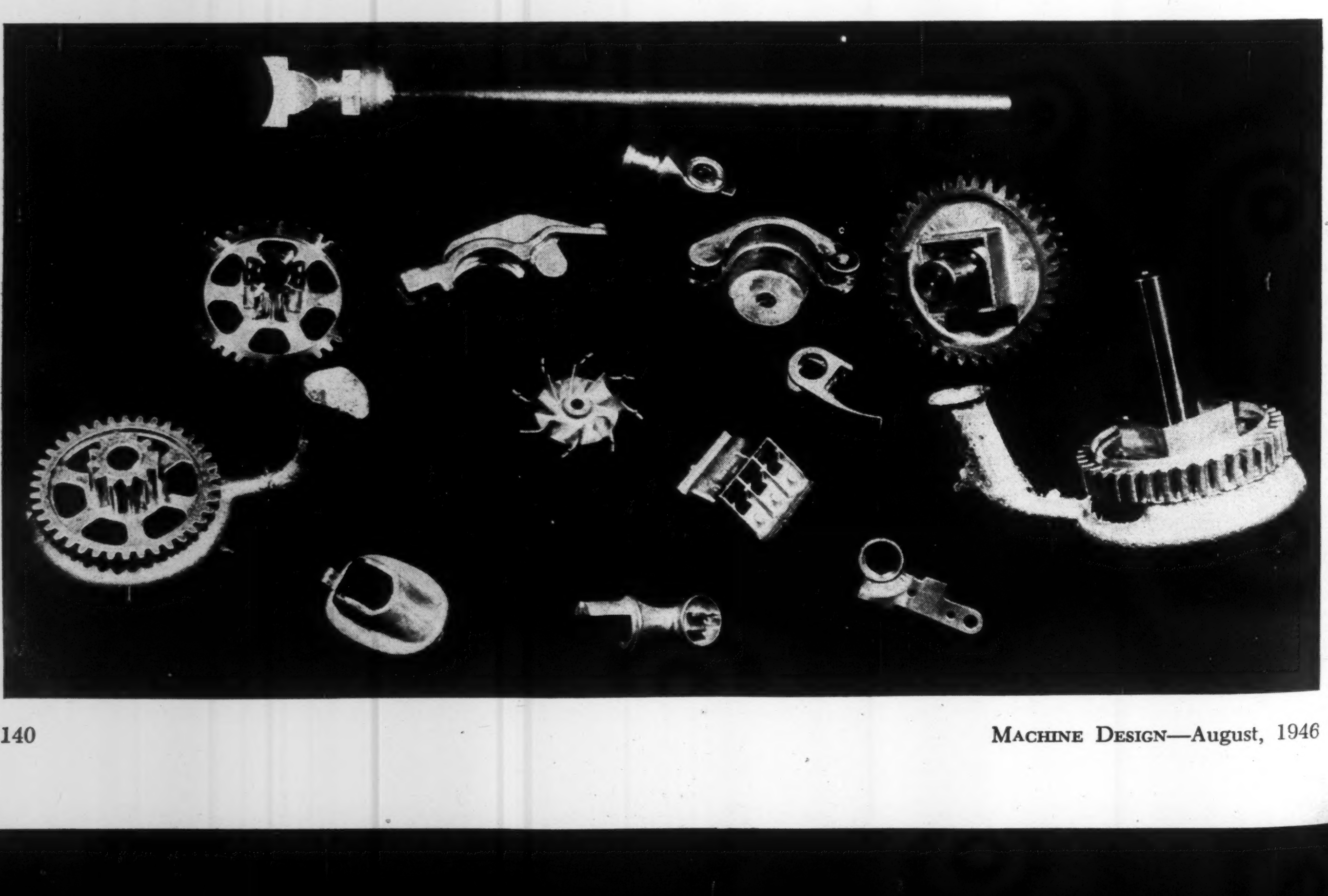
Permanent-Mold or Die Cast?

Merits of each casting method for copper-base alloys are compared to assist in selection

By Herbert Chase
Mechanical Engineer
Forest Hills, New York

BOTH die castings and permanent-mold castings have long competed with sand castings, even when the latter were available in unlimited quantities and at much lower prices than now prevail. Current shortages in sand castings make it more important than ever for design engineers to recognize and be conversant with the advantages of castings that are producible in metal molds.

Fig. 1—Below—Group of permanent-mold castings, including gears with and without sprue and runner



Basically, the metal-mold casting has the great advantage that once the mold (or the die as it is usually called) is made, it serves to produce many thousands of castings. With sand castings, of course, a new mold has to be made for each casting or gate of castings. Naturally, many other factors have to be considered but, in general, metal mold castings have much to recommend their use. In this article, consideration will be given only to the casting of copper-base alloys in gravity-poured permanent molds,

Fig. 2—Left—Ball retainer for an anti-friction bearing, a remarkable die casting in silicon-bronze because of the thin wall sections

Fig. 1, and in dies under pressure.

Several factors enter into a choice between these two types of castings, quite aside from the maximum weight, which is controlled in part by the size of machine available. It can be said, however, that die casting is favorable to parts having thin sections not only because of the limited amount of metal handled per shot but also because castings with thin walls chill rapidly and thus help to shorten the casting cycle and keep average die temperature lower, thereby serving to prolong die life. It is also possible, with metal injected at about 22,000 psi pressure, to fill out sections much thinner than in casting with a gravity head only, as in permanent-mold work.

Casting Methods Compared: In die casting brass, the metal is introduced into a so-called "cold chamber," or part of a cylinder containing a ram, following which the ram is advanced by hydraulic means to force the metal through runners and gates into the die which is locked under heavy pressure. A slug of metal is always left at the end of the ram and this, attached to the casting by metal that fills the runners and gate, is ejected along with the casting.

For producing permanent-mold castings, the die is made in two or more pieces and can be parted either horizontally or vertically or both. Molten metal is poured in from a hand ladle and flows through a sprue hole, runner and gates into the bottom of the cavity, rising to fill the latter. As no pressure is applied save the gravity head, a simple and inexpensive machine is adequate to hold, lock and open the dies.

In both types of casting, as much as one-half the metal used in casting may be required for sprue, slug, runners and gates that are cut off and remelted. Some flash appears at die partings and is commonly removed by trim dies. In permanent-mold castings, the runner is often an anuular ring cut off when the part is machine, *Fig.* 1.

Casting Rate: Die-casting dies commonly are filled (under pressure) from 400 to 800 times per eight-hour shift as against about 150 times for permanent molds. Thus, when parts are producible by either method, die casting is faster but requires at least one man for each machine whereas, for permanent-mold casting, an average of one man to four or five machines is usually sufficient. Thus, there may be little difference in labor charges per casting. In addition, each type of machine can make some castings that the other cannot.

Alloys Used: For permanent-mold castings aluminum-bronze is often employed, other copper-base alloys being less fluid and too sluggish to be applied with ordinary molds and methods. With aluminum-bronze, however, strong, sound and hard castings are easily secured. This alloy has a high liquid shrinkage, making it somewhat hard on dies and cores so that considerable allowance for die maintenance has to be made. Representative composition and properties of one aluminum-bronze alloy are given

Fig. 3—Below—Aluminum-bronze worm gear, with steel shaft insert, produced in a permanent mold. Teeth, cast close to size, require only a light hobbing cut for finishing

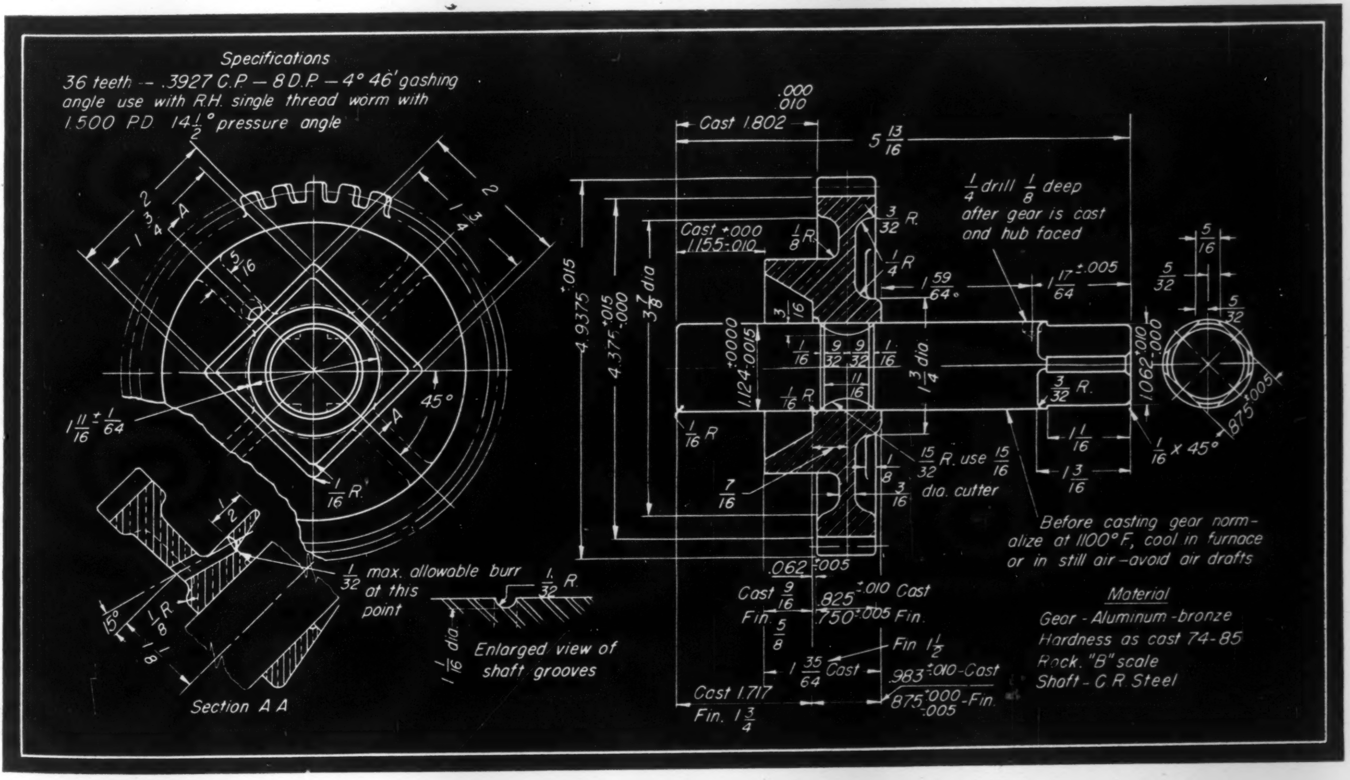
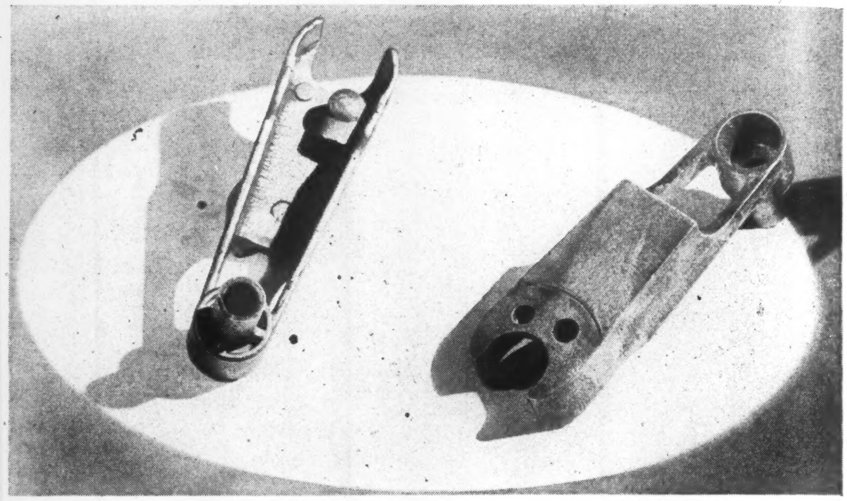

Specifications
36 teeth -- .3927 C.P. — 8 D.P. — 4° 46' gashing angle use with R.H. single thread worm with 1.500 P.D. 14½° pressure angle
2
1¾
A
5/16
45°
1 11/16 ± 1/64
1/16 R.
1/2
1/32 max. allowable burr at this point
1/32 R.
15°
1/8 R
1/8
1/16 dia.
Enlarged view of shaft grooves
Section A A
4.9375 ±.015
4.375 +.015 -.000
3 7/8 dia
Cast +.000 1.155 -.010
Cast 1.802 .000 .010
5 13/16
1/8 R
3/32 R.
1/4 R
3/16
1/16
9/32
9/32
1/16
11/16
1/16 R
1.124 +.0000 -.0015
1 3/4 dia.
1 59/64
1 17/64 ±.005
1/4 drill 1/8 deep after gear is cast and hub faced
5/16
5/32
5/32
1.062 +.010 -.000
3/32 R.
.875 ±.005
1/16 x 45°
1 1/16
1 3/16
1/16 R
7/16
15/32 R. use 15/16 dia. cutter
1/8
3/16
Before casting gear normalize at 1100° F, cool in furnace or in still air—avoid air drafts
.062 ±.005
Cast 9/16
Fin. 5/8
.825 ±.010 Cast
.750 ±.005 Fin.
Fin 1½
1 35/64 Cast
.983 ±.010-Cast
.875 +.000 -.005 -Fin.
Cast 1.717
Fin. 1¾
Material
Gear - Aluminum-bronze
Hardness as cast 74-85 Rock. "B" scale
Shaft - C.R. Steel

Fig. 4—Right—Typical yellow brass die casting with marked variations in adjacent section thicknesses

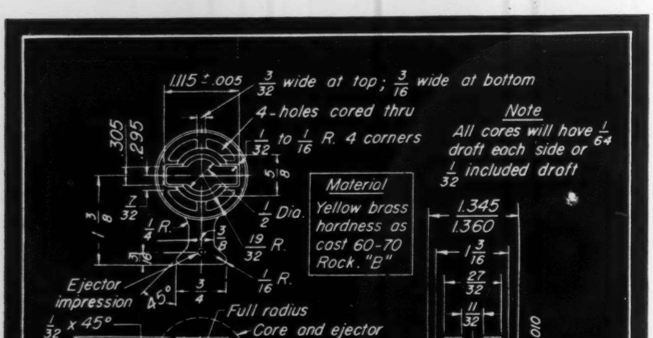


in TABLE I. High strength and resistance to wear and corrosion make this alloy well suited for many parts such as gears with teeth cast close to size, *Fig.* 1. Hardness can sometimes be increased by heat treatment.

Almost any brass or bronze can be die cast but, for economy and lower die maintenance costs, two alloys are commonly used. The cheaper one, which can be made from secondary metal, is yellow brass of the general composition given in TABLE I. This brass is not so strong and has a higher melting point than the second alloy, which contains silicon and has better casting properties. This alloy, called silicon-brass or silicon-bronze, is harder to machine and polish than yellow brass. However, lighter walls can be cast in silicon-bronze, 0.030 to 0.040-inch being practical, *Fig.* 2. Tensile and yield strengths, and hardness, of the silicon alloy are about the same as those for aluminum-bronze cast in permanent molds but the silicon-bronze is less ductile. The table also gives some comparative physical properties as well as normal compositions.

SMOOTHNESS OF CASTINGS: In general, both permanent-mold and die castings are smoother than sand castings, while sand inclusions never are present to dull tools used for machining. When dies are new, die castings may be as smooth as permanent-mold castings but, as dies are used, heat checking results in fine cracks in die surfaces. With permanent molds and gravity pouring, the metal is not forced into the heat cracks, and castings remain reasonably smooth. However, with die castings the high pressure applied forces metal into die cracks and leaves corresponding raised "veins" or crazing on the castings. Being above the surface, this roughness can be removed without excessive polishing of castings but average smoothness, throughout the useful die life, is apt to be better on the permanent mold castings unless the die-casting die has its checked surfaces renewed.

Fig. 5—Brush holder die cast in yellow brass with the brush hole and recesses cored out to maintain light, uniform sections throughout


1.115 ± .005
3/32 wide at top; 3/16 wide at bottom
4-holes cored thru
1/32 to 1/16 R. 4 corners
Note
All cores will have 1/64 draft each side or 1/32 included draft
.305
.295
5/8
Material
Yellow brass hardness as cast 60-70 Rock. "B"
7/32
1 3/8
1/4 R.
1/2 Dia.
3/8
19/32 R.
3/16
1/16 R.
Ejector impression
45°
3/4
1.345
1.360
1 3/16
27/32
11/32
Full radius
1/32 x 45°
Core and ejector flash on this side
1.125
1.140
.905
.890
63°
1/8
.100 ± .010
Flash & burrs on this side from trim & grind operations
1 3/16
.056 +.000 -.015
1 3/32
1.370
1.386
1.370
1.386
Fractional limits ± 1/64

Die castings are ejected from the die with pushout pins that often leave blemishes on the cast surfaces. Such marks, though readily ground off, are avoided in permanent-mold castings where no pushout pins are used, partly because of differences in die construction and partly because castings are usually quite hot and comparatively soft when ejected.

Die Costs Higher for Gravity Casting

DIE COSTS: For dies to make equivalent castings, first costs are about the same whether the casting is made by the gravity or pressure method, as the same heat-resisting steel is used in either case. If, however, the same daily production is required, two to four dies for gravity casting may be needed as against one for die casting under pressure, making die cost higher for gravity casting. On the other hand, roughening of the die for pressure castings may make it necessary to spend more for die maintenance unless greater roughness in the castings can be tolerated.

SECTION THICKNESS: As previously indicated, sections can be considerably thinner in die-cast than in permanent-mold castings. For the latter, ⅛-inch is about the thinnest section usually feasible although it is possible, on occasion, to use somewhat thinner sections if they do not extend over a large area and are not so disposed that shrinkage, which is high (about 2 per cent), does not result in cracking. In die casting, sections should be as thin as conditions permit though not less than 1/16-inch as a rule. Ring-shaped ball retainers 5 inches in diameter and only 0.030 to 0.040-inch thick, *Fig.* 2, with uniform walls have been die cast and look almost as if drawn from sheet brass.

Uniform section thickness is desirable in both types of casting (as in all castings, for that matter) but marked variations in thickness within the same casting, *Figs.* 3 and 4, are common and usually do not involve serious difficulties unless thin areas are so located that shrinkage causes cracking. It is always best to make the transition from thick to thin sections as gradual as possible and to use generous fillets, especially at inside corners.

Thick sections are more advantageous in permanent-mold than in die castings although they sometimes result in shrink marks where progressive solidification is not attained. There is no fixed maximum thickness in either form of casting, but economy in metal, as well as rapidity in casting, result where sections are not excessively heavy. Where shrinkage cracks occur in thin sections connecting thicker ones, as in a gear or wheel web between thick hub and rim, trouble sometimes can be avoided by equalizing shrinkage through provision of a ridge to give thicker metal at some point about half way between.

Porosity: There is apt to be much less porosity in permanent-mold than in die-cast parts largely because, in the permanent mold, metal is fed more slowly, rising gradually in the mold and pushing air out through the vents. In contrast with this, flow into the die casting is abrupt and turbulent so that at least small air bubbles usually are trapped in the casting no matter how well the die is vented. By proper gating, venting and use of overflow wells, however, porosity can be minimized and confined to areas where it is of little or no significance. Porosity is more likely to occur in thick than in thin sections and often can be reduced by coring to effect thinner walls. In permanent-mold castings, thick sections in conjunction with high shrinkage may result in shrink marks, though rarely in voids. However, skill in die design can avoid shrink marks or make them of no significance.

TABLE I

Representative Copper-Base Permanent-Mold and Die Casting Alloys

Type of Casting	Permanent-Mold (Gravity cast)	Die-Cast (Cold chamber)	Die-Cast (Cold chamber)
Metal	Aluminum-bronze	Silicon-bronze	Yellow brass
Composition (%)			
Copper	85-88	80-83	58-62
Iron	2-3	....	....
Aluminum	10-11	....	....
Silicon	....	3.5-4.5	....
Lead	....	....	1 max.
Tin	....	....	1 max.
Zinc	....	13-16	36-41
Physical Properties			
Tensile (psi)	75,000-85,000	75,000-85,000	50,000-60,000
Yield (psi)	36,000	40,000	35,000
Elongation (% in 2-in.)	17-26	6-8	10-12
Hardness (Rock. B)	75-85	75-90	60-70
Electrical Conductivity (Copper as 100%)	12	7	26
Specific Gravity	7.5	8.3	8.5
Weight (lb/cu. in.)	0.27	0.297	0.30
Melting Point (F)	1870	1575	1700

Coring: Metal cores, either fixed or movable, are often used in both types of casting to provide holes or recesses and to economize in metal as well as to help keep sections uniform in thickness, *Fig.* 5. Often a core, say through a boss, helps avoid porosity, as well as excessive machining and difficulty in drilling.

It is possible to do more complex coring in die-cast than in permanent-mold castings, largely because of differences in die construction and in core-pulling facilities. Cores as small as ⅛-inch in diameter can be used in die casting if they are not too long. Slender cores may be bent by metal impact or nonuniform heating and also may suffer from "burning." Core-pulling attachments on most permanent-mold machines require that movable cores be vertical and most fixed cores, unless quite short, are so arranged. Cores less than 3/16-inch in diameter are not recommended.

Cores for both types of casting are exposed to high temperatures, erosion and high shrinkage, which commonly result in high stresses and mechanical wear. For this reason, cores have to be replaced often, especially when the dimensions they control must be accurate.

Dimensional Tolerances as Cast: Usual dimensional tolerances for brass die castings are plus or minus 1/64-inch but, where dimensions are small and conditions permit frequent renewal of critical die parts, dimensions can be held within plus or minus 0.005-inch limits. Minimum allowances on the general run of parts, however, have to be plus or minus 0.005-inch per inch or more,

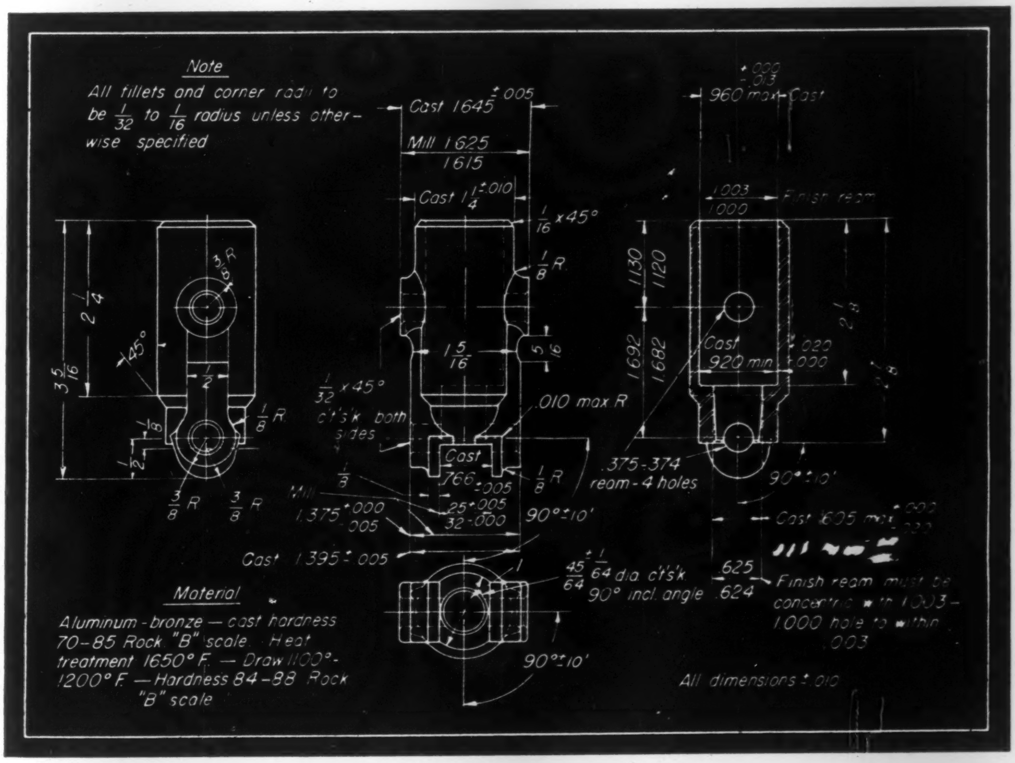

Note
All fillets and corner radii to be 1/32 to 1/16 radius unless otherwise specified
Cast 1645 ±.005
Mill 1625 / 1615
Cast 1 1/4 ±.010
1/16 x45°
1/8 R
3/8 R
2 1/4
3 5/16
45°
1/2
1/8 R
1/8
1/2
3/8 R
3/8 R
1 5/16
5/16
1/32 x45° c'ts'k both sides
.010 max R
Cast .766 ±.005
1/8
1/8 R
Mill 1.375 +.000 -.005
25 +.005 / 32 -.000
90° ±10'
Cast 1.395 ±.005
45/64 ±1/64 dia. c'ts'k 90° incl. angle
90° ±10'
Material
Aluminum-bronze — cast hardness 70-85 Rock "B" scale. Heat treatment 1650° F. — Draw 1100°-1200° F. — Hardness 84-88 Rock "B" scale
+.000 -.013 .960 max — Cast
1.003 / 1.000 Finish ream
1.130 / 1.120
1.692 / 1.682
Cast .920 min
+.020 / -.000
2 1/8
2 1/8
.375-.374 ream - 4 holes
90° ±10'
Cast .605 max +.000 -.020
.625 / .624
Finish ream must be concentric with 1.003-1.000 hole to within .003
All dimensions ±.010

***Fig.* 6—Aluminum-bronze permanent-mold casting with a deeply cored central hole. Drafts used are clearly indicated**

depending on the particular conditions that apply.

For permanent-mold castings, it is best to allow minimum tolerances about twice as great as for brass die castings, although there are cases where specific dimensions as close as for die castings can be held. Wider tolerances are needed because the machines used do not hold dies as accurately, and casting temperatures and casting shrinkages are greater. On the other hand, unless the dies for the high-pressure die casting have critical surfaces renewed frequently, change in dimensions affected may exceed those for the permanent-mold casting.

Close Tolerances Must be Justified

For maximum economy, therefore, it is best not to specify that any dimensions be held, as cast, closer than is absolutely essential, at least until the caster is consulted as to effects on costs. The cost of holding the best tolerances that *can* be held under favorable conditions may be excessive. Where machining is involved, the limits held depend upon the machines and tools used and can be as close as it is feasible to work with these machines and tools though, again, costs have to be considered.

Draft Angle: As with all metal-mold castings, there must be sufficient draft to permit cores to be pulled and castings to be ejected from the die, *Fig.* 6. The usual minimum draft on a side is 0.020-inch per inch of length or "draw." In specific cases, especially where the casting shrinks away from the wall without binding elsewhere, less draft may be permissible, but in such cases the caster should first be consulted.

Except where larger drafts involve excessive machining or unfavorable appearance, generous drafts should be provided to permit easier ejection of the casting with less chance of distortion or marking and less mechanical wear on core and die parts. This, in turn, may help to lower casting costs.

Inserts: With both die castings and permanent-mold castings, steel or other metal inserts can be used and precisely and firmly positioned, *Fig.* 7. This is an important advantage over sand castings (in which metal inserts are not favored). The insert must be of such shape that it can be properly positioned in the die and should have deep knurling or undercuts where the cast metal is to freeze around the insert so as to lock the latter firmly into the casting. Many gears can be cast on ground shafts that are precisely centered with respect to the pitch line of the gear teeth.

A disadvantage of inserts is that they slow the casting cycle somewhat because it takes extra time to place the insert in the die. This is offset, however, by savings over machining a hole, perhaps with a key, and applying an insert after the part is cast.

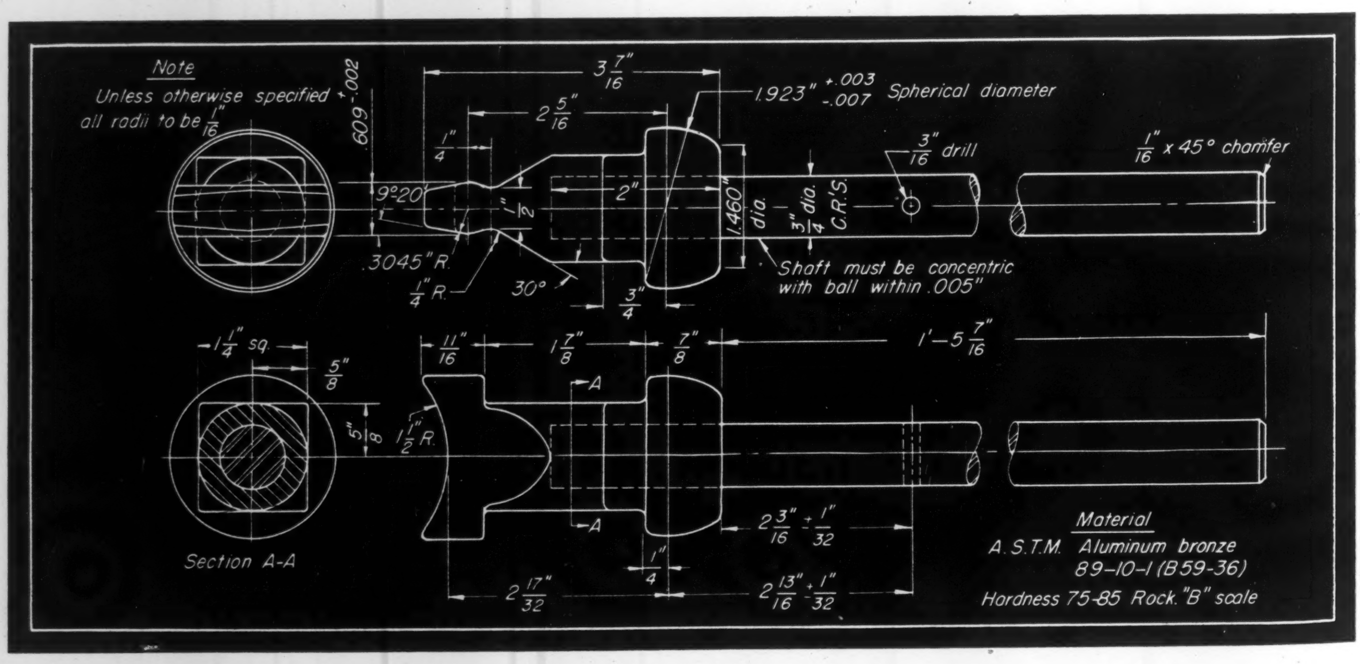
Machining Properties: Although yellow brass is the easiest of the three alloys here dealt with to machine, it is considered harder to machine than annealed wrought yellow brass. The silicon and aluminum-bronzes are much harder to machine but present no unduly difficult machining problems, especially when carbide tools, which are recommended, are used.

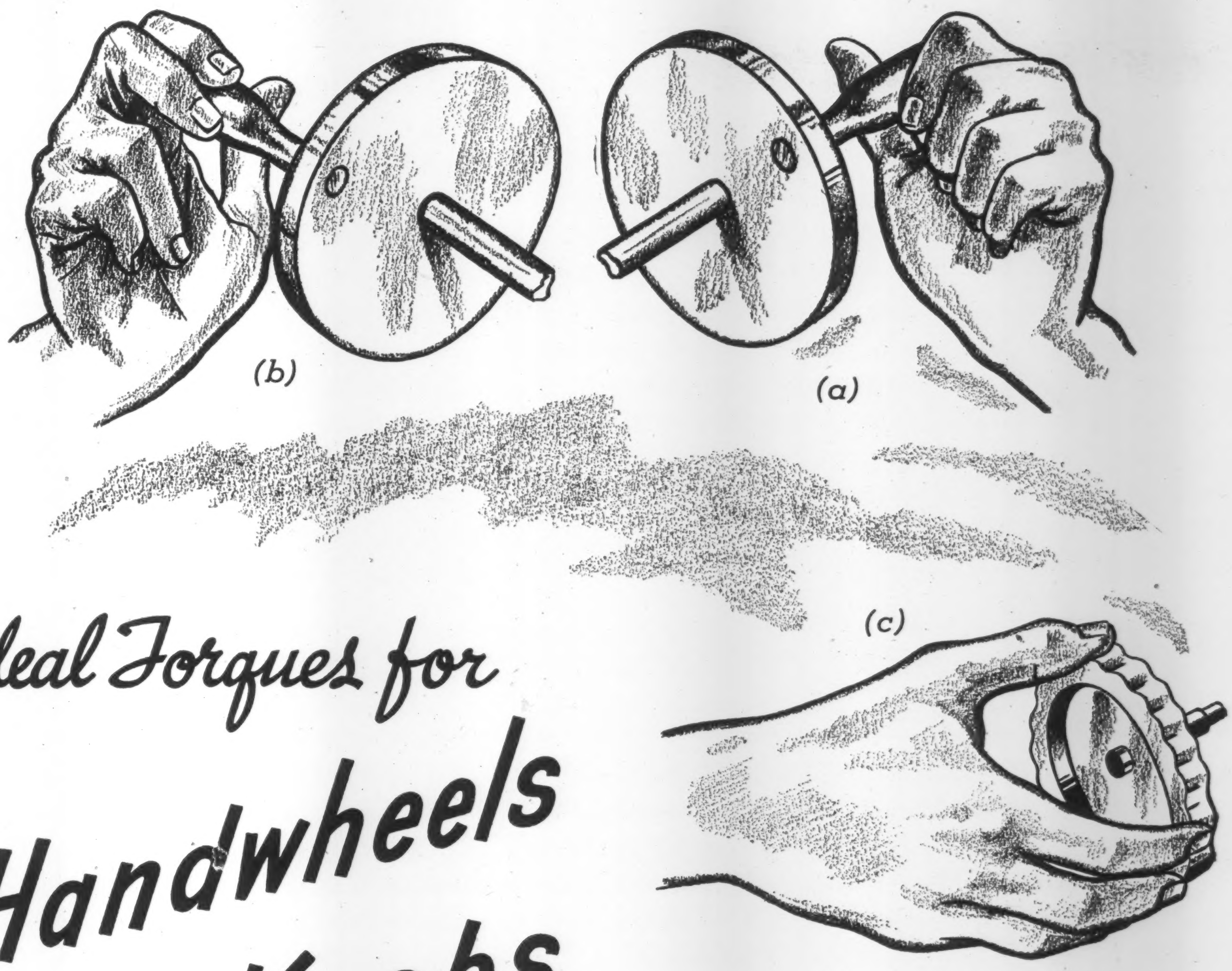
Finishing Operations: Finishes suited for use on copper-base alloys are applicable to the castings here described. Surface smoothness commonly favors ease of finishing. Polishing and buffing for plating are somewhat more difficult on the silicon or aluminum-bronze than on the yellow brass castings. As the permanent-mold castings are relatively free from porosity, baking at high temperature does not cause blistering such as may occur on die castings, but finishes that are baked below temperatures likely to cause blistering are available.

Preceding considerations and study of accompanying illustrations make it evident that both die and permanent-mold castings in copper-base alloys have significant advantages and a definite place in the design of machine parts.

The author is indebted to the McGill Mfg. Co., Valparaiso, Ind., for the illustrations and coverage of industrial practice as outlined in this article.

Fig. 7—Unusual clutch shifter, cast in permanent mold in aluminum-bronze, with a steel shaft insert





Ideal Torques for Handwheels and Knobs

Results of a series of practical tests include preferred torques for handwheels, and an empirical equation for knobs

By Arnold Raines and J. H. Rosenbloom
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HANDWHEELS and knobs should, in most applications, require such torques that maximum accuracy will be obtained within the limitations of muscular ability. Reports[*] indicate that, for maximum accuracy in direct positioning, the dry friction should be zero, and the inertia torque should be the maximum that the physical limits of the operator will permit. However, inasmuch as the existence of the dry friction is generally unavoidable, this article is concerned only with those limitations to be imposed on the torque because of the muscular effort involved. For this purpose, the origin of the torque, i.e., whether inertia, viscous or dry friction, is unimportant.

The strenuosity of a muscular activity can be measured

Fig. 1—Above—Methods of grasping handwheels and knobs. (a)—Conventional thumb grasp for handwheel. (b)—Three finger grasp for handwheel. (c)—Finger grasp for knob uses all fingers

by the maximum duration that an individual can engage in such activity. Activities with handwheels and knobs can be specified in terms of their torques, speeds, diameters and methods of grasping, i.e., the muscles used. *Fig.* 1 indicates various methods of grasping. In handwheels the handle can rotate freely about its axis, the handle being grasped in one of two obvious manners, *a* and *b*, while the outside circumference of a knob is commonly slotted for a firmer grip. Bounds of the strenuosity range can be determined experimentally with relative ease as will be shown in the discussion to follow by a combination of experimental data and analysis based on tests.

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[*] NDRC Division 7 Report No. 74.

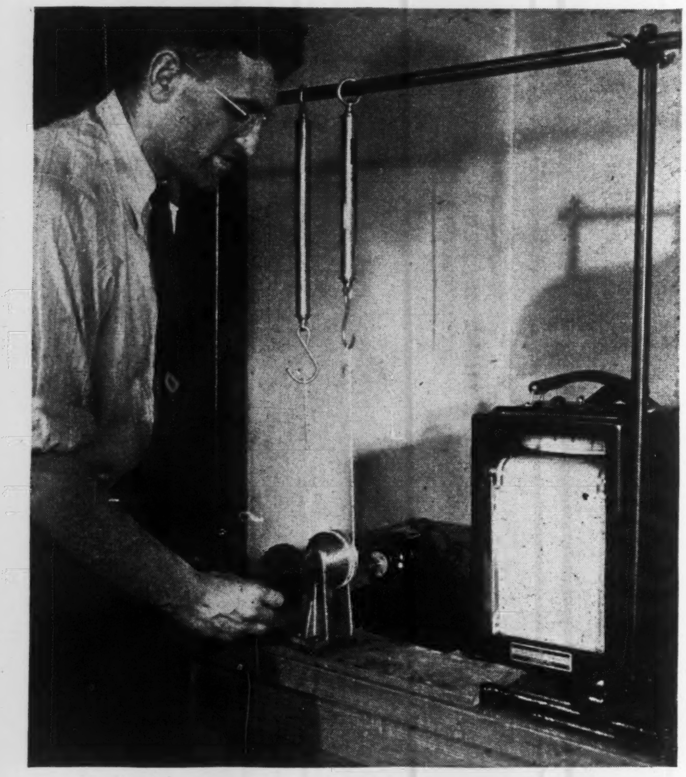
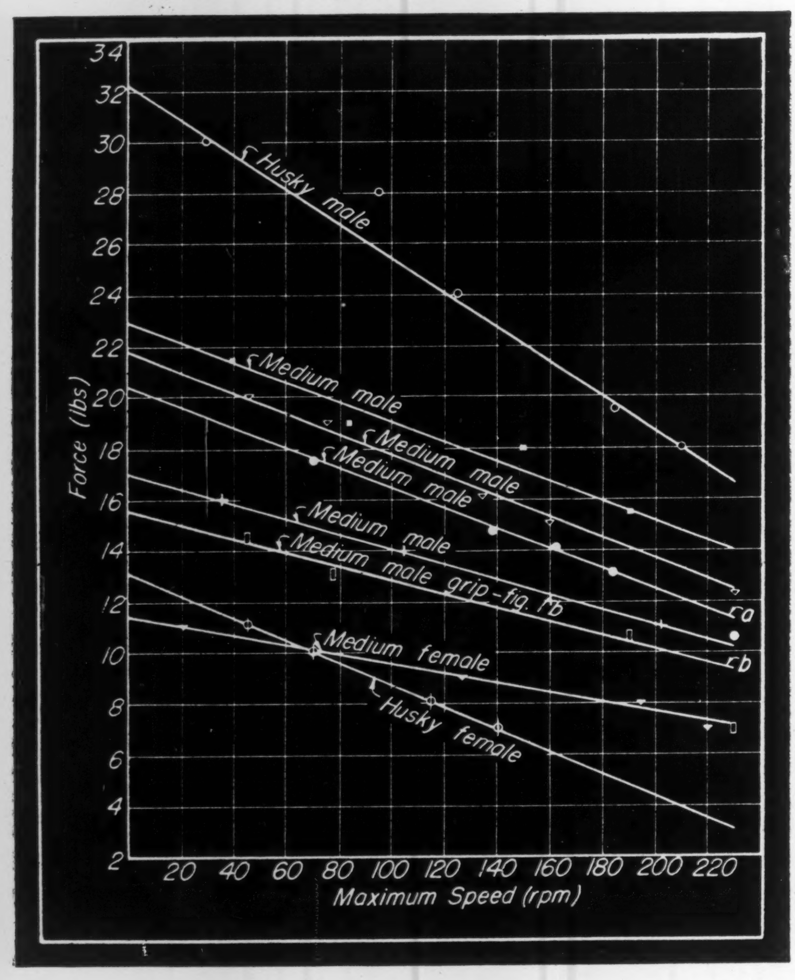


Fig. 2—Above—Author Rosenbloom runs a handwheel test. The speed determination instruments are seen to the right.

Fig. 3—Below—Maximum exertion for 1½ in. dia. handwheel. Grasp is as in Fig. 1a with the exception of curve b. This curve is for the grip shown in Fig. 1b



Speed Tests

Test Procedure: The experiments upon which this article is based were conducted in the following manner. For a given handwheel, torque, and method of grasping, the operator was instucted to exert himself to the limit so as to rotate the handwheel at the maximum possible speed for about one second. This took place upon a test setup conceived as representing typical conditions see *Fig.* 2. Handwheels from 1½ to 7½-in. in diameter were mounted on a horizontal shaft about waist high with respect to the standing operator. Friction torques were supplied by a rope under tension wrapped around a pulley attached to the horizontal shaft. Tension in the rope was varied by two constrained spring seales attached to the free ends of the rope.

Resulting curves for the 1½ in. diameter handwheel for a representative group of operators are given in *Fig.* 3. Within the range considered, the curves are straight line for each operator. It will be noted that the first point was generally below the operator's curve, a phenomenon probably associated with a "warming up" period. The effect of method of grasping can be noted from *a* and *b* which refer to the same operator holding the handwheel in different manners. With larger diameter handwheels the forces for the lower maximum speed increase because of the use of the more powerful muscles of the arm. However, at the higher maximum speeds effects of the more powerful muscles are balanced out by the required greater linear travel, resulting in an overall negative increase in the slope of the lines.

Physiological Basis: There exists a physiological criterion for the strenuosity of muscular effort which will be useful for deducing the order of magnitude from the data in *Fig.* 3. Ordinarily, the strenuosity of an activity may be identified, except for its effect on the nervous system, with its degree of fatiguing. Now a measure of the degree of fatigue of a muscle is the extent of the accumulation of lactic acid above normal, a certain maximum occurring when complete fatigue sets in. During a steady muscular exertion, the oxygen intake of the muscles involved may be sufficient so that there will be no increase in lactic acid. Under these conditions, the activity may continue indefinitely, or until a lack of glycogen occurs.

Thus, a criterion of the strenuosity of muscular activity is the oxygen debt—defined as the difference in oxygen intake required by the muscle for the activity, less the oxygen intake during the activity. The foregoing criterion was found very useful for analyzing the data, although the experimental procedure was not used. However, as can be observed from *Fig.* 3, the variation among operators is so great—the most powerful giving values three times that of the weakest—that practical answers for specification use are obtainable from the subjective feelings of a representative sample of observers, obviating extensive apparatus for measuring oxygen cosumption.

Torque Tests

In the torque tests, the operators were instructed to rotate the handwheel for about 10 seconds at a slewing rate of 100 rpm or above—to do this at different torques and to decide upon the torque above which they would not like to rotate the handwheel under practical conditions. All operators had had considerable experience with handwheels, especially those requiring precise adjustment. The test group ranged from girls of sedentary habits to powerful mechanics, although the majority of operators were medium-built males of an average of 28 years. The result is given in *Fig.* 5 which shows the force as a function of diameter for ten operators.

Characteristics: The following characteristics of the curves may be noted:

1. With the evident exception, the average slope of the curves is slight. This is due to the fact that there are two opposing tendencies at work with the varying-diameter handwheels. Larger diameters permit use of the more powerful muscles of the arm but, simultaneously, smaller diameters require less linear travel for the same angular velocity.
2. Intermediate values do not vary by more than 25 per cent from the straight line joining the points at extreme diameters, indicating that each operator cooperated closely in the experiment and that he analyzed his reactions with care.
3. Certain of the more powerful operators gave lower curves than the weakest, showing the importance of the subjective feeling of the operators in reaching their decision.
4. An average of the curves is a horizontal line with a value of 5.5 lb. Assuming a safety factor of 25 per cent, 4 lb may be then taken as the maximum force that a handwheel should offer to the operator, for handwheels with diameters between 1½ and 7½ in., and at slowing rates about 100 rpm.

Maximum and Preferred Forces: If it be considered how the value of 4 lb fits in with the picture in *Fig.* 3 depicting maximum values, it will be found that an order-of-magnitude answer is obtainable from the following considerations, which can also be used for estimating the complete strenuosity range based on physiological considerations.

A subject weighing about 150 lb exerting his whole body to the utmost in running, can acquire an oxygen debt of 20-25 liters per minute with an average total maximum debt of 7 liters. In general, for an indefinite duration of an activity as discussed above, the oxygen intake is about 2.0-2.5 liters per minute, or one-tenth the value at maximum exertion. This value is considered to constitute no actual debt. Now assume that the exertion of the muscles of the operator to obtain the values of *Fig.* 3 corresponds to the 20-25 liter per minute exertion of the runner for his whole body, and that the mechanical efficiency is the same. Then the median operator of *Fig.* 3 will exert a force of 13/10 or less than 1.3 lb for indefinite operation. A similar argument may be pursued to determine the maximum force that can be applied. It will be noted that extreme exertion results in a 22.5 liters per minute oxygen debt, a

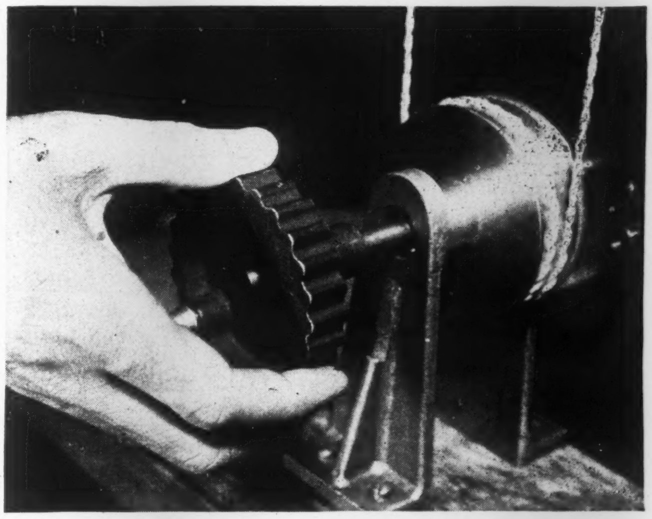
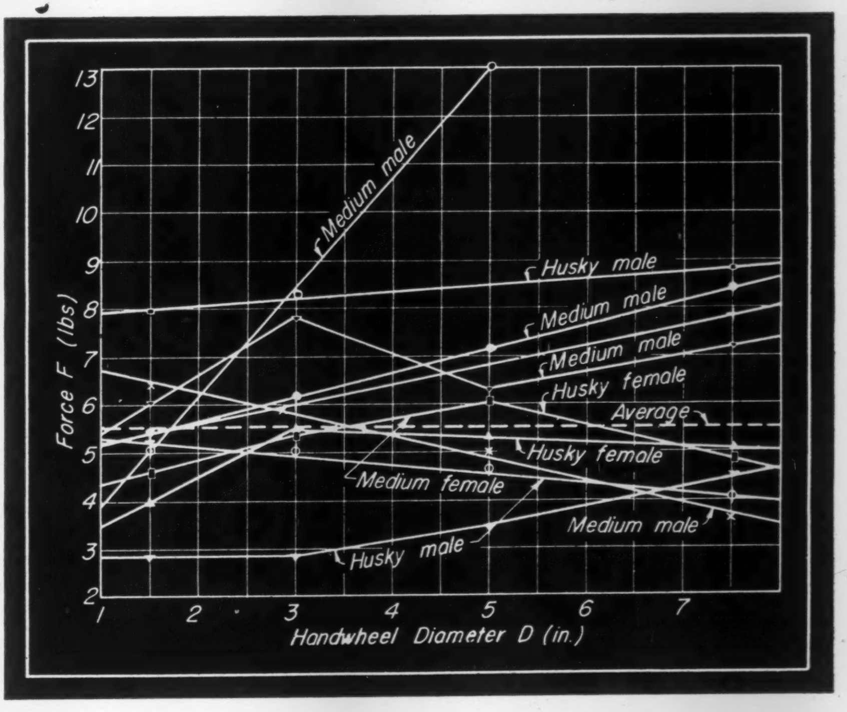


Fig. 4—Above—Close-up of the knob test. Method of torque application through a capstan arrangement may be noted on the shaft

Fig. 5—Below—Preferred maximum muscular exertion for handwheel slewing. The average value curve is indicated at a constant value of 5.5 pounds



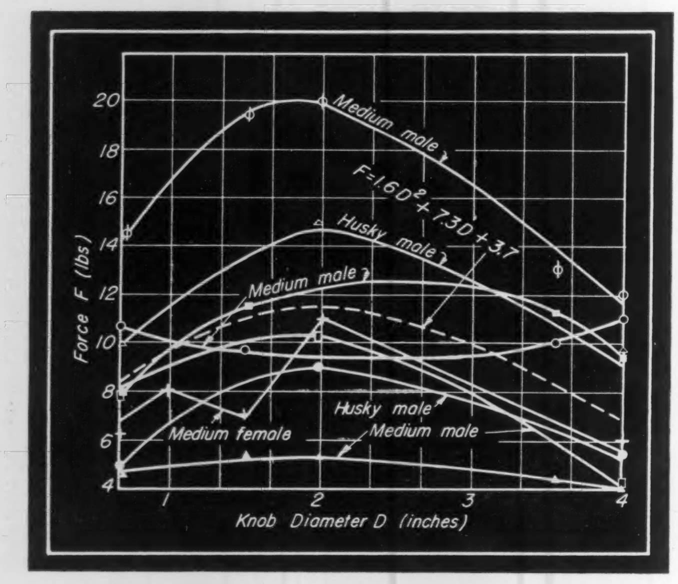


Fig. 6—Preferred maximum muscular exertion for knob setting. The average curve approximates a parabola

condition which may be compared with the 13 lb maximum force at a slewing rate of 100 rpm. From this follows the proportion: $7/22.5 = x/13$ and x, the maximum force exertable is found equal to 4 lb. Now since an activity of 2 liters per minute can be continued indefinitely, the actual oxygen debt for extreme exertion is $7-2=5$ liters per minute. Then the 4 lb force can be sustained for $7/5 = 1.4$ minutes.

Knobs: For knobs, the speed is unimportant. Practical values for specification of force was obtained in a manner similar to that used for handwheels, see *Fig.* 4. Knobs studied varied from 0.7 to 4 in. in diameter. Operators were instructed to grasp knobs as in *Fig.* 1c, rotate through about 90 degrees for different torques, and indicate the maximum torque above which they would not like to rotate knobs in practical operation. Again, the operators were experienced and varied in strength. *Fig.* 6 shows the results obtained. As the diameter of a knob increases, the maximum force increases due to the fact that more powerful muscles of the hand come into play. Eventually, however, the maximum force decreases because the size becomes too large for convenient grasping. The average curve may be approximated by a parabola for the diameters considered, the empirical equation for which is:

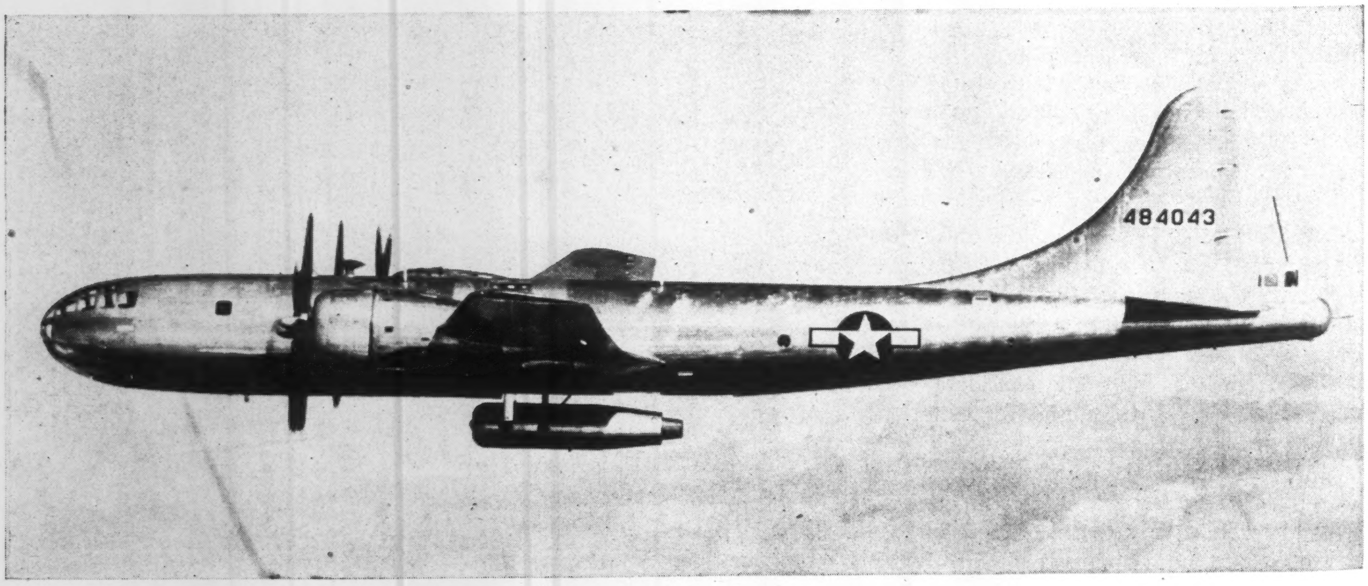
$$F = 1.6D^2 + 7.3D + 3.7$$

where F is force in pounds, and D is diameter in inches. As a safety factor, 25 per cent should be deducted.

Conclusion: It follows that conclusions should be separately made for handwheels and for knobs. In the case of handwheels within the diameters discussed, allowing the 25 per cent safety factor, maximum force specified should be 4 lb. For knobs, it is believed that the foregoing empirical equation represents a satisfactory operating condition. In addition, owing to the inconvenience of manipulation, it is felt that knobs of less than one inch diameter and of over three inches diameter should be avoided wherever the design makes this possible.

Flying Laboratory Tests Jet Engines

FOR STUDYING aircraft equipment under actual flying conditions this B-29 Superfortress is, in effect, a wind tunnel in reverse. Modified for the Army Air Forces by engineers of the General Electric Co. the flying lab provides complete instrumentation for the measurement of engine and electronic equipment performance, as well as sufficient space for technicians. Shown suspended from the bomb bay of the giant plane is a torpedo-shaped, axial-flow, turbo-jet engine for study under flight conditions. Three planes have been so equipped.



MACHINE *Editorial* DESIGN

Putting Practice into Education

OFTEN the criticism is heard that our engineering colleges and universities are failing to provide students with adequate training for a career in mechanical design. The college graduate, say the critics, is not "practical" and his theoretical background is of little use.

The need for a continuing flow of top-grade men into the design profession is too vital to be left as the sole responsibility of "the other fellow"—in this case the professor. Textbooks generally seem to be written by professors themselves, hence tend to perpetuate an approach which does not always move with the times. Sound and clearly written though these books may be, the relation between their contents and many current design problems sometimes appears remote. There is a real opportunity for qualified chief engineers and designers to pass on their accumulated knowledge and experience by setting down in textbook form the fundamentals and techniques of machine design as they apply today, and thus to assist in insuring that the young men whom they expect to add to their staffs in the years to come will have the right background.

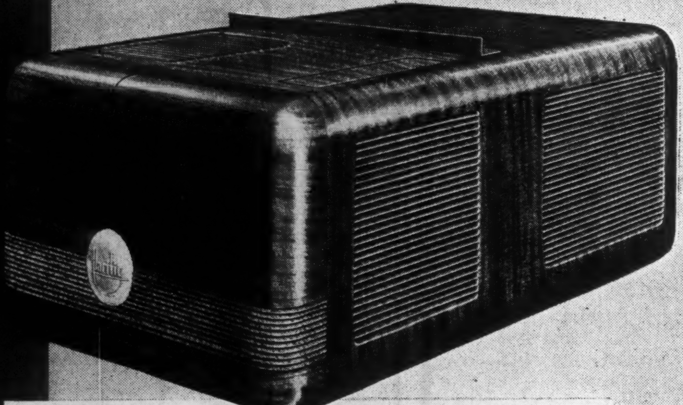
But the textbook, however good, is not enough. Upon the instructor rests the responsibility of breathing life into the subject and supplementing the book with information on new developments. A number of forward-looking colleges and machinery manufacturing companies have instituted plans whereby instructors and designers trade their jobs for a few hours each week, with striking benefits to all concerned. Thus the students benefit from direct contact with experienced designers having the viewpoint of industry; the regular professors benefit from getting their teeth into some specific engineering problems; the companies benefit from the fundamental viewpoint brought into their engineering departments by the professors; and last, but not least, the designer turned temporary professor benefits from the stimulation of contact with fresh minds and from the necessity of getting back to fundamentals himself. Designers in localities near engineering schools should be on the alert for such opportunities.

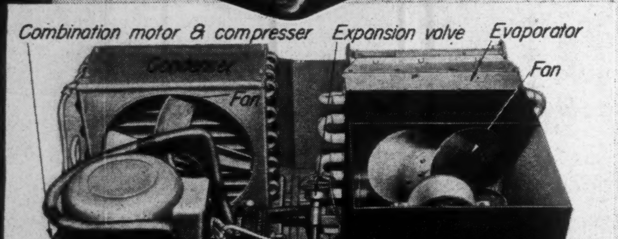
Finally there is the need for information on current developments to supplement the textbook which, necessarily, cannot always be up to date. For this the instructor relies on published information in technical magazines and engineering society journals. Again the designer can help by making available in articles and papers his experience with the techniques of design and the application of fundamentals. No one is better fitted to resolve the apparent differences between theory and practice and to refine current theories to the point where students as well as practicing designers can effectively put them to work.

Contemporary Design

Air Conditioning Machine

FUNCTIONS of summer air conditioning provided by this machine include refrigeration, ventilation, filtration, circulation and dehumidification. Interior of the cabinet is partitioned into two chambers—a "hot", or condenser, side and a "cold", or evaporator, side—by a ¾-inch thick Fiberglas board.

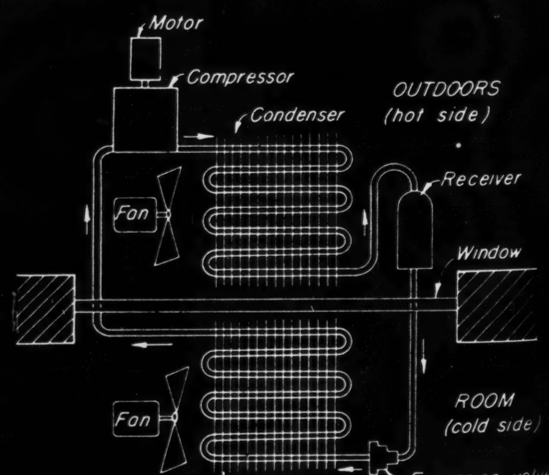




A twin-cylinder, ½-hp, hermetically-sealed Freon compressor is employed, the motor of which is direct connected and operates in a bath of oil inside a welded case. This eliminates belts, noise from wearing parts and also increases trouble-free life. The compressor is statically and dynamically balanced and has an induction-hardened crankshaft ground to a 15-microinch finish, flapper-type one-piece suction valve with controlled lift, and pistons of chrome-nickel iron with case-hardened steel piston pins.

Operation of the unit, shown in the schematic drawing (below) is as follows: The refrigerant goes through the compressor which it leaves at relatively high temperature and then passes into a fin-type condenser (heat exchanger) adjacent to the compressor. From there it passes into a cylindrical receiver and on through an expansion valve into a fin-type evaporator (heat exchanger or cooling coil).

To change the high-pressure, high-temperature Freon from gas to liquid by withdrawing heat from it as it passes through the condenser, a motor-driven fan is employed. This draws outside air in at one side of the cabinet, passes it through the condenser and out of the cabinet. For changing the liquid refrigerant back to gas as it passes through the evaporator, another motor-driven fan is used. This one pulls room air through a cabinet grille and filter, and on through the evaporator which extracts heat from the air. The air, cool and filtered, then passes through the outlet grille and into the room.

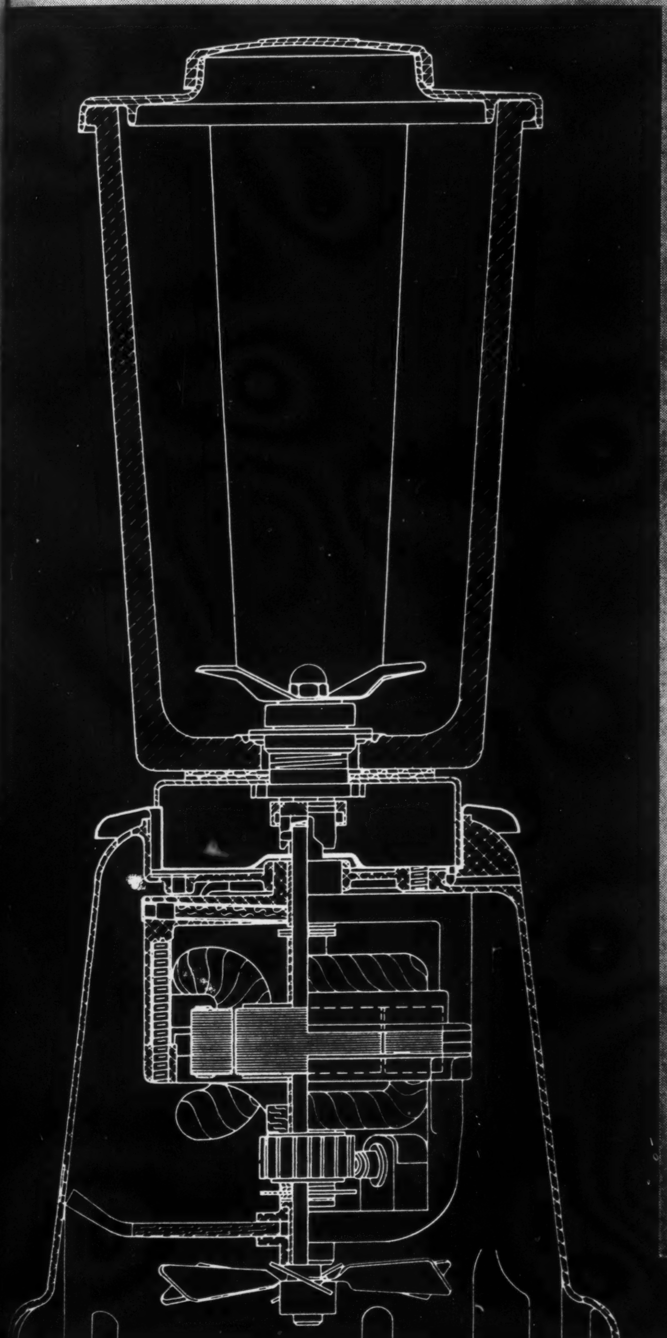


This completes the cycle of the refrigerant and it goes back from the evaporator to the compressor.

As the air is forced through the evaporator its moisture is condensed into water and flows into a pan directly under the evaporator. This water then flows to the hot, or condenser, side of the unit and, with the use of another heat exchanger, is evaporated into the out-of-doors atmosphere.

On the room side of the unit there is a three-way electric switch which turns the complete unit off, turns the complete unit on, or turns on only the cold side, thereby circulating inside and outside air through the filter and room without refrigeration or dehumidification. All component parts are mounted on rubber or spring mountings or a combination of both in order to eliminate vibration and noise.

Cabinet of the unit is 22-gage rust-proofed steel, chemically cleaned, painted and grained in two contrasting simulated wood finishes. All corners and edges are rounded to generous radii and the various inlet and outlet grilles are integrally formed in the cabinet in the shape of louvers. Interior of the cabinet is lined completely with 1-inch thick Fiberglas blanketing to minimize noise and heat transmission. Manufacturer: Pacific Manufacturing Co., Cleveland.



Home Mixer and Liquidizer

BASICALLY this machine, known as a Liquidizer, consists of a glass bowl containing a set of special stainless steel blades rotating at high speed (14,000 rpm). The blades are designed so that solids are rapidly chopped into small particles and, at the same time, agitated vertically.

To facilitate pouring of the mixed ingredients, the bowl is removable and is provided with a lid of red cellulose-acetate-butyrate plastic. This lid will not

stain, nor will it contaminate the food. It is made in two pieces so that there will be no splashing when additional food material is added while the machine is operating. This is accomplished by removing the center cap instead of the entire lid. Flexibility of the lid permits snapping it in place over the rim of the glass bowl and also prevents breakage of the lid in the event it is dropped.

Power is supplied by a universal motor mounted in the die-cast base. This motor rotates a flexible coupling which, regardless of the spindle position, meshes with the driving spindle of the cutter blades when the glass bowl is replaced on the base. Two bracket-type die castings encase the motor, allowing a maximum dissipation of heat which results in a cool running appliance. Air is continually circulated over the motor by a fan located near the bottom cover plate of the base. This cover plate is provided with ventilating openings which are made of such size that ordinary kitchen utensils cannot be inserted to damage the motor parts.

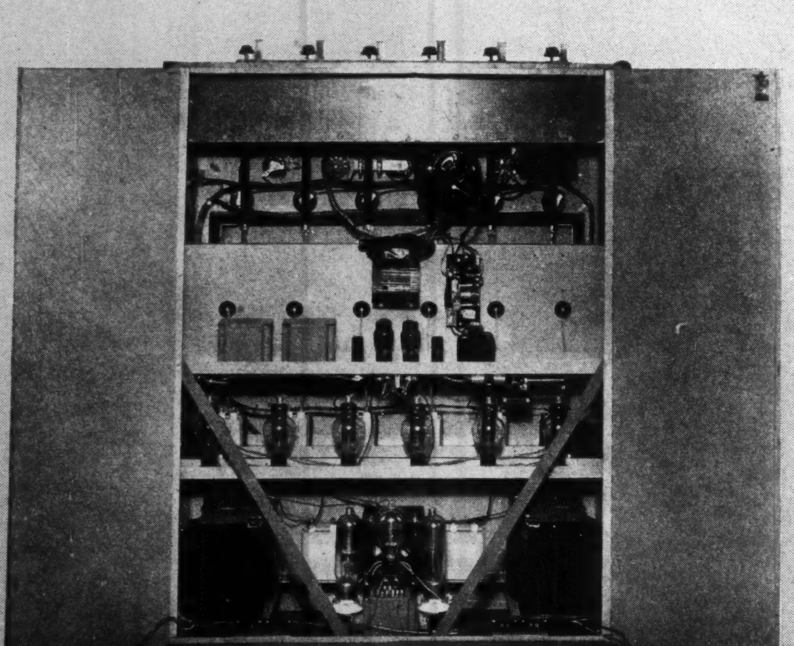
To permit various types of mixing operations, a switch is provided to initiate two speeds. For heavy cutting, as in the case of ice cubes and fibrous vegetables, the machine customarily is operated at high speed. For more gentle mixing and blending of the shredded material, the switch is turned to low-speed.

For prevention of undesirable vibration, the unit is mounted on flexible rubber feet which are inserted into sockets in the die-cast base. Finish on the base is white synthetic enamel of high luster, and all visible metal parts are high-polished chrome-plated brass. Manufacturer: Knapp-Monarch Co., St. Louis, Mo.

New Magneto Coil Tester

THIS MACHINE gives a high-potential running test to six coils simultaneously without the need for assembling each coil separately into a regular magneto. Behind glass windows at the top of the machine are six spark gaps, the upper grounded electrode of each being attached to a threaded, knobbed rod used to make adjustments.

Because nitrous oxide is produced by sparking, a blower is used to give ventilation. Air is taken from within the cabinet and, after passing through the gaps, leaves through a hole in the top. Sound insulation is provided by one-inch thick wood walls, a double glass window and felt-covered steel plates in the incoming and outgoing air passages in back of the gaps.



Below the spark gaps is the control panel consisting of filament and power switches, an overload circuit breaker, two tap switches giving two per cent steps in input voltage, a frequency switch providing five steps from 100 to 500 sparks per second, and individual disconnecting switches for each coil. Below the control panel is the coil compartment with an interlocked glass door.

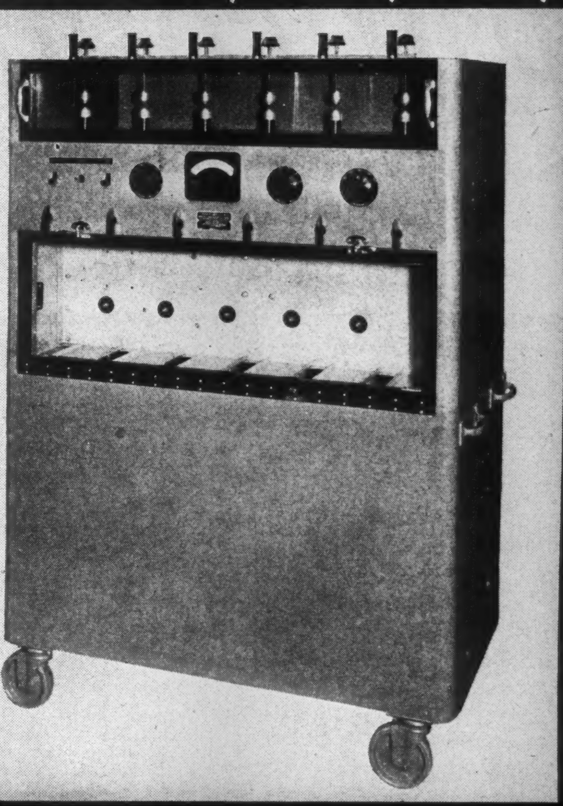
In the upper left of the circuit diagram is shown a direct-current power supply which at full load will supply 400 volts and 2 amperes. A 3-ampere instantaneous overload relay in the power transformer ground lead gives protection against short circuits caused by failure of any thyratron to deionize. The direct-current power passes through a rectifier to charge the 0.5-mf capacitors through the 1-H reactors. Purpose of the rectifier is to allow the capacitors to retain their voltage which goes to twice the direct-current voltage because of the reactors. Individual tap switches in each circuit provide for opening through two steps of resistance to prevent overvoltage by the sudden interruption of reactor cur-

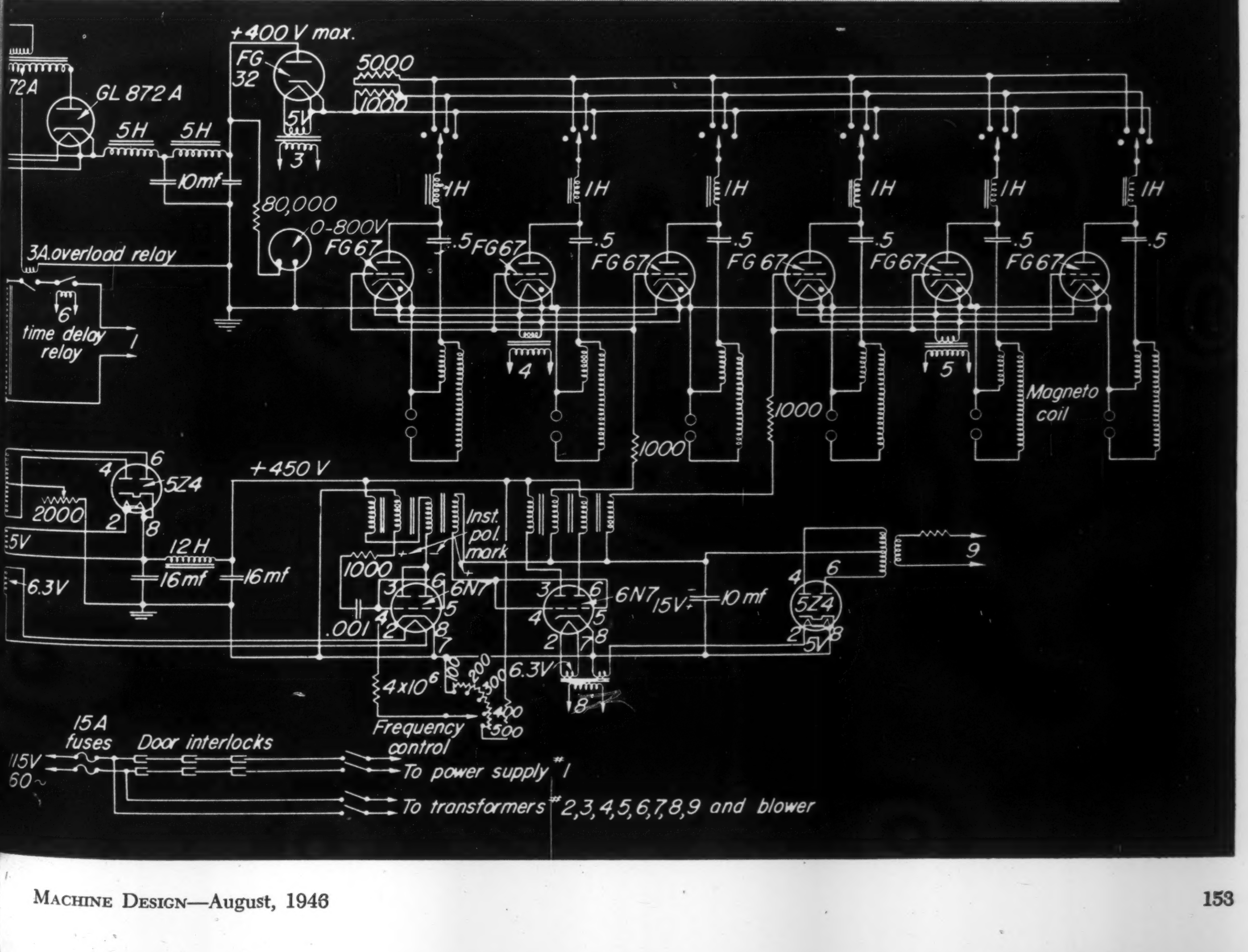
Contemporary Design

rent. Firing of the thyratrons places the 0.5-mf capacitor and the coil primary in series, starting an oscillatory discharge which is stopped when the current tries to go through zero and reverse. At this time the capacitor is in a condition of partly reversed charge, thereby helping the thyratron to deionize.

Tripping of the thyratron and the resulting spark at the gap is controlled by the circuit shown on the lower part of the diagram. This consists of a pair of 6N7 tubes and coupling transformers with the necessary power supplies. The 6N7 at the left is connected as a blocking oscillator and the one at the right as a pair of amplifiers. Instantaneous polarity marks on the coupling transformers indicate the polarities due to rising plate current in the oscillator tube. Each amplifier takes care of tripping three thyratrons. The first to trip makes its grid a few volts positive which in turn fires the other two.

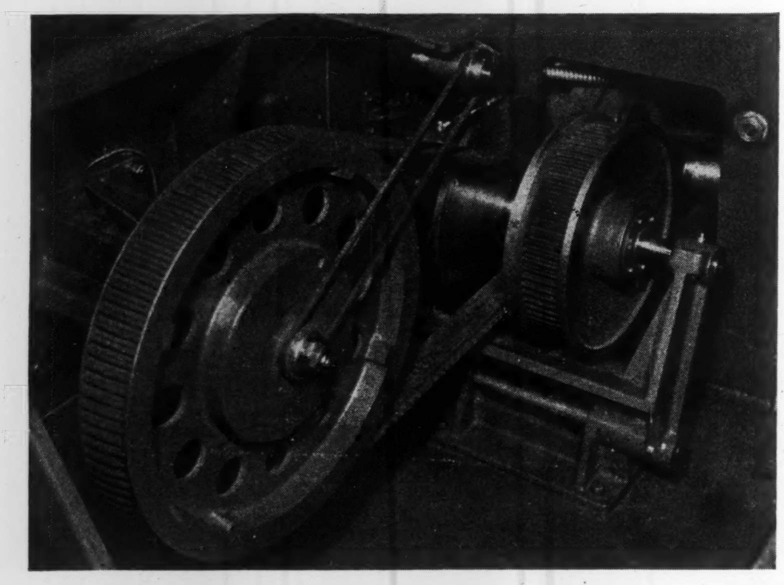
The coil compartment contains six steel trays upon which is mounted a coil holder. In the back wall of the compartment are six terminals for connection to the coil primaries. Gap terminals extend down from above. Manufacturer: General Electric Co., Schenectady, N. Y.




+400 V max.
FG 32
5000
1000
5V
3
72A
GL 872A
5H
5H
10mf
80,000
0-800V
FG 67
FG 67
FG 67
FG 67
FG 67
FG 67
1H
1H
1H
1H
1H
1H
.5
.5
.5
.5
.5
.5
3A overload relay
6
time delay relay
1
4
5
1000
1000
Magneto coil
4
6
5Z4
2000
2
8
5V
12H
16mf
16mf
6.3V
+450 V
Inst. pol. mark
1000
3
6
6N7
4
5
.001
2
8
7
3
6
6N7
4
5
2
7
8
15V
10 mf
4
6
5Z4
2
8
5V
9
4x10^6
200
300
400
500
6.3V
8
Frequency control
15A fuses
Door interlocks
115V 60~
To power supply #1
To transformers #2,3,4,5,6,7,8,9 and blower

Applications

of Engineering Parts, Materials, and Processes

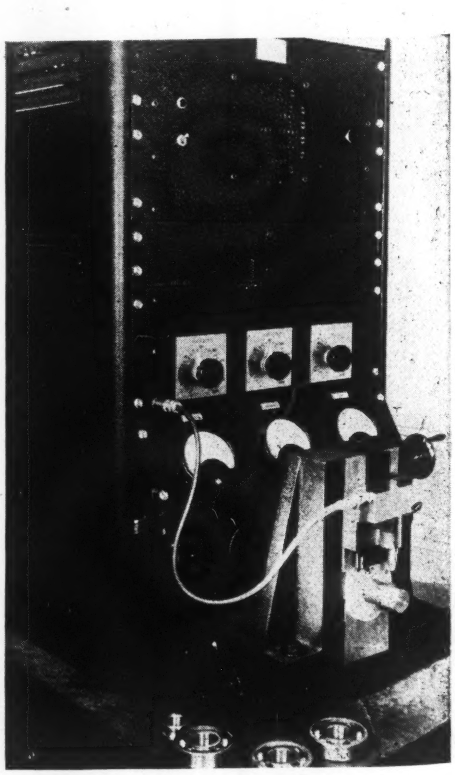


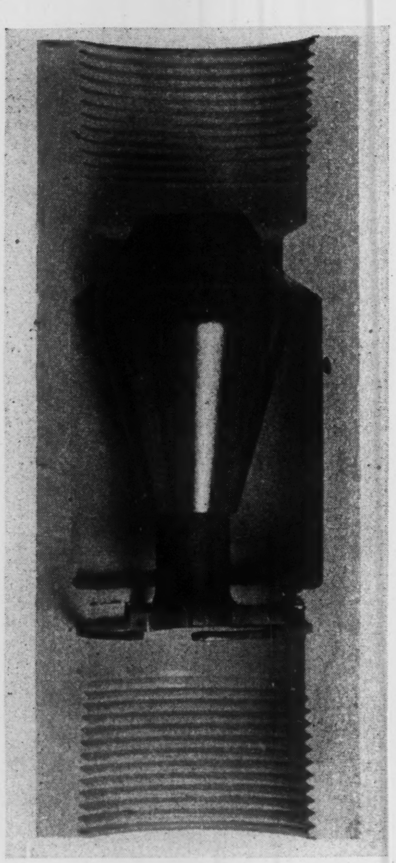
Facilitates Speed Changes

INCREMENTAL speed changes over a wide range are made possible in the metal-cutting band saw, left, by means of the Speedmaster double-groove belt-driven pulley. The idler pulley has a floating center member positioned between the incoming and outgoing belts. When the idler is moved in the direction of either the driving or the driven pulley, belt tension forces the floating center member to either one side or the other, increasing one pitch diameter while decreasing the other. In this manner, speed-change ratios as high as 40 to 1 have been achieved.

Analyzes Bearing Irregularities

FACILITATING analysis of the causes of bearing irregularities, the Anderometer, below, rapidly and quantitatively checks assembled bearings for deviations of both balls and races from true circularity. The bearing is slipped on to a revolving spindle and a pick-up touches the stationary outer race. Cycles of radial motion are noted on one of three meters covering three frequency ranges. In this manner, irregularities caused by manufacturing operations may be studied. The machine measures variations in terms of microinches and angles.





Low Inertia Poppet

TWO-THOUSAND psi check-valve, shown at left, utilizes aluminum alloy for the poppet member, resulting in a drastic decrease in weight. Positive opening and closing action is achieved. Manufactured by Greer Hydraulics, Inc., the entire assembly is composed of but five parts, the housing, poppet, aluminum guide, spring, and retaining ring. A 50,000-cycle test—fully open to fully closed—showed no appreciable wear.

Section Properties of Fillets

By Victor M. Kibardin
Professional Engineer
Glen Ridge, N. J.

Part I—Oblique Fillets

DEMANDS for lighter weight in machine frames and other structures are increasing the need for cut-outs. Accurate calculations of the strength and stiffness of the resulting structure are somewhat hampered by the absence of readily available tables or formulas for section properties of shapes other than rectangular. In particular, where fillets are encountered and especially where only a portion of the fillet is eliminated from the original section, or the subtended angle is other than 90 degrees, revision of the section properties to allow for the cut-outs becomes a major problem.

Fillets also enter into weight and strength calculations of extrusions, castings, forgings, etc. Again, existing standard tables of section properties are not sufficiently broad in scope to cover fillets involving circular arcs from 0 to 180 degrees.

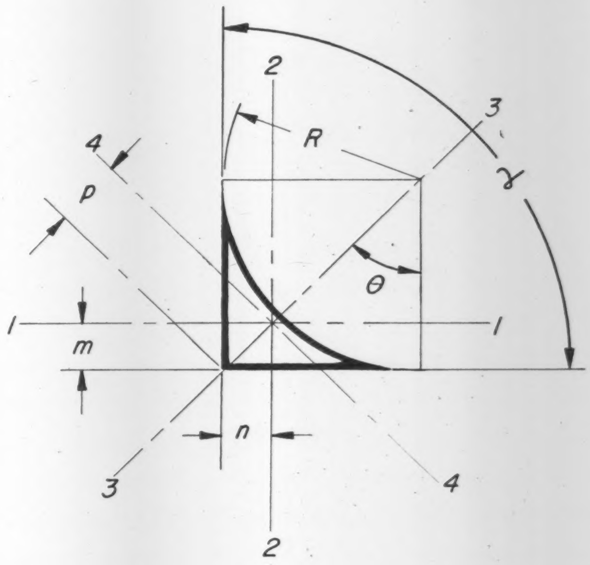
Since the fillet itself generally constitutes a relatively small proportion of the original section it is usual to employ some form of approximation in calculating the fillet. While this may be justified where the margin of safety is high, there are instances when the designer must contend with a drastically cut-out section, and must employ an exact method.

In this and the following data sheet methods are presented for readily obtaining section properties of fillets, including exact formulas and tables as well as quick, comparatively accurate methods based on the use of data for whole, 90-degree fillets. The present data sheet is concerned with oblique fillets while Part II, which will appear next month, covers fractional fillets.

For whole, 90-degree fillets, the leading section properties are given by the equations in *Fig.* 1. The numerical coefficients contain enough significant figures to enable the designer to employ any desired degree of accuracy.

Oblique fillet properties may be quickly estimated from *Fig.* 2, in conjunction with the calculated values for a whole 90-degree fillet, *Fig.* 1. The factors plotted on the chart are equal to the ratios of the section properties of the oblique fillets to those of whole 90-degree fillets of the same radius, *R*.

Exact formulas for the properties of oblique fillets are given in *Fig.* 3. On the same page there appears a table of numerical coefficients for oblique fillets from which the section properties may be calculated by multiplying by the appropriate power of *R*, the fillet radius.



Area

$$A=0.21460184R^2$$

Location of neutral axis 1-1

$$m=0.22336795R$$

Location of neutral axis 2-2

$$n=0.22336795R$$

Location of neutral axis 4-4

$$p=0.31588999R$$

Moment of inertia about axis 1-1

$$I_1=0.00754512R^4$$

Moment of inertia about axis 2-2

$$I_2=0.00754512R^4$$

Moment of inertia about axis 3-3

$$I_3=0.01198379R^4$$

Moment of inertia about axis 4-4

$$I_4=0.00310644R^4$$

Fig. 1—Principal dimensions for whole 90-degree fillets, with exact equations for section properties

ENGINEERING DATA SHEET

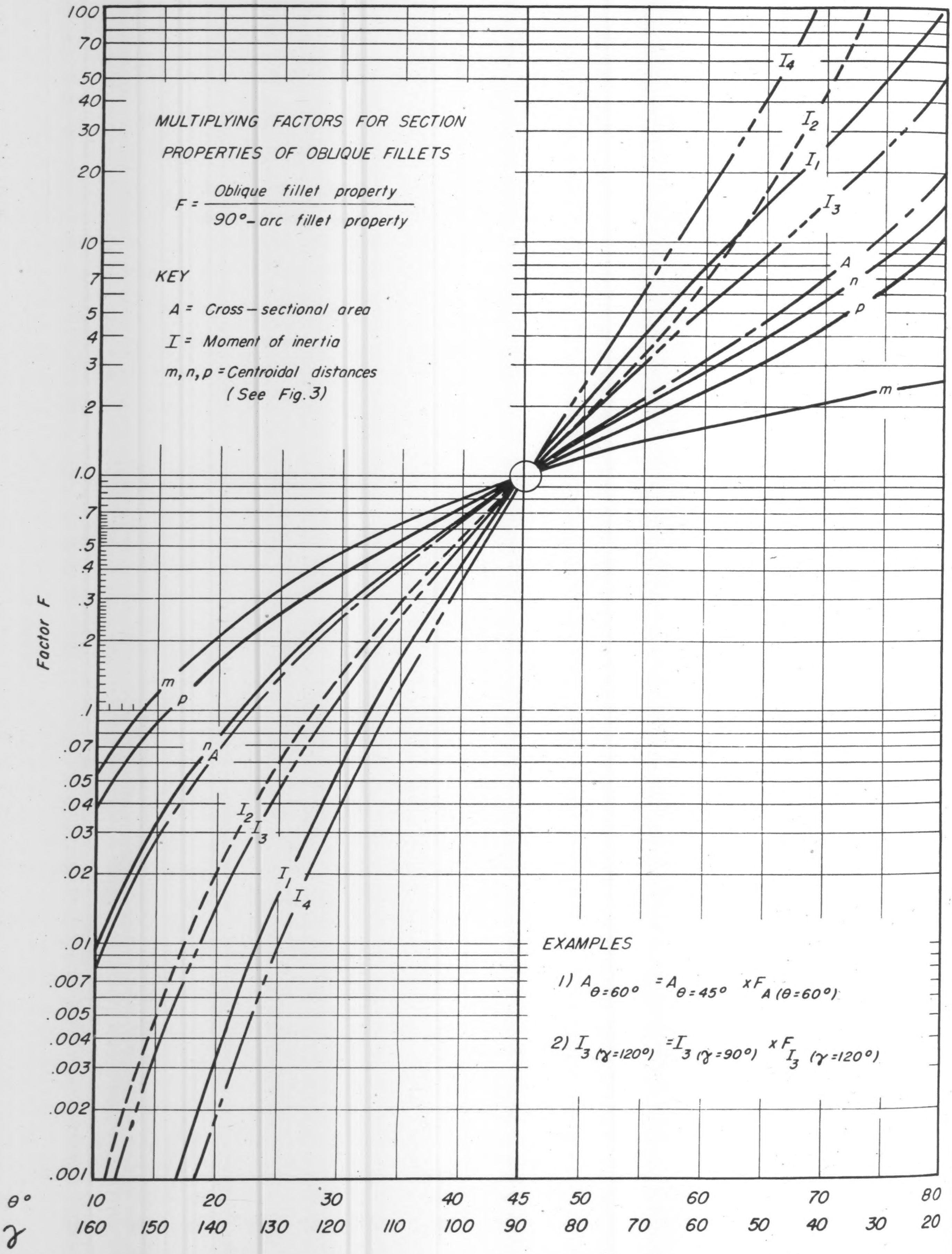


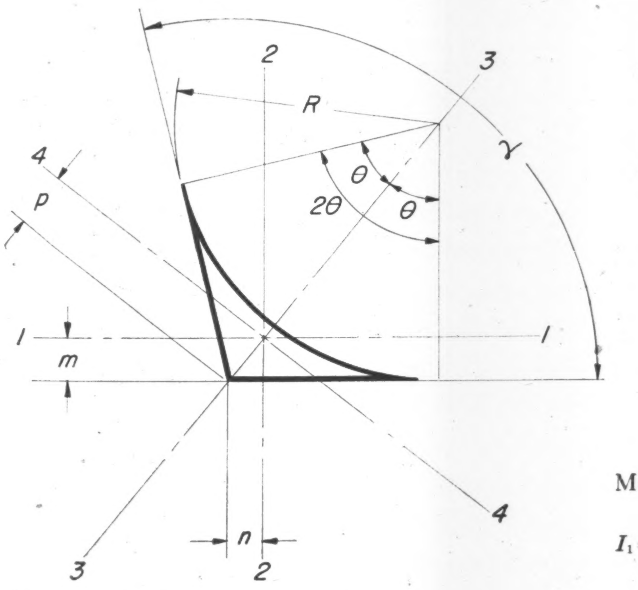
Fig. 2—Above—Chart for rapid determination of section properties of oblique fillets, based on 90-degree fillets

Fig. 3—Opposite Page—Leading dimensions of oblique fillets, with exact equations for section properties

ENGINEERING DATA SHEET

Section Properties of Oblique Fillets

Fillet Angle (degrees)		Area Factor	Axes 1-1 and 2-2				Axes 3-3 and 4-4		
			Neutral Axis Factor		Moment of Inertia Factor		Neutral Axis Factor	Moment of Inertia Factor	
γ	θ	$\frac{A}{R}$	$\frac{n}{R}$	$\frac{m}{R}$	$\frac{I_{1-1}}{R^4}$	$\frac{I_{2-2}}{R^4}$	$\frac{p}{R}$	$\frac{I_{4-4}}{R^4}$	$\frac{I_{3-3}}{R^4}$
160	10.0	0.00179	0.00214	0.01215	0.000000	0.000005	0.01234	0.000000	0.000006
155	12.5	0.00353	0.00419	0.01889	0.000001	0.000016	0.01935	0.000000	0.000017
150	15.0	0.00615	0.00726	0.0271	0.000004	0.000039	0.0280	0.000001	0.000042
145	17.5	0.00987	0.01159	0.0367	0.000010	0.000083	0.0385	0.000002	0.000091
140	20.0	0.01490	0.01739	0.0477	0.000026	0.000158	0.0508	0.000006	0.000178
135	22.5	0.0215	0.02492	0.0601	0.000060	0.000278	0.0651	0.000014	0.000324
130	25.0	0.0299	0.0344	0.0738	0.000124	0.000460	0.0814	0.000031	0.000553
125	27.5	0.0406	0.0462	0.0887	0.000242	0.000722	0.1000	0.000063	0.000901
120	30.0	0.0537	0.0605	0.1049	0.000443	0.001088	0.1211	0.000121	0.001409
115	32.5	0.0698	0.0778	0.1221	0.000774	0.001582	0.1448	0.000223	0.00213
110	35.0	0.0893	0.0984	0.1405	0.001299	0.00224	0.1715	0.000396	0.00314
105	37.5	0.1128	0.1226	0.1598	0.00210	0.00309	0.201	0.000685	0.00451
100	40.0	0.1409	0.1512	0.1802	0.00330	0.00420	0.235	0.001154	0.00635
95	42.5	0.1745	0.1845	0.2013	0.00505	0.00565	0.273	0.001909	0.00879
90	45.0	0.21460	0.22337	0.22337	0.00755	0.00755	0.31589	0.00311	0.01198
85	47.5	0.262	0.268	0.246	0.01105	0.01008	0.364	0.00500	0.01614
80	50.0	0.319	0.321	0.269	0.01590	0.01355	0.419	0.00796	0.0214
75	52.5	0.386	0.382	0.293	0.0225	0.01846	0.481	0.01262	0.0283
70	55.0	0.468	0.458	0.317	0.0315	0.0256	0.554	0.01997	0.0372
65	57.5	0.566	0.537	0.342	0.0436	0.0365	0.637	0.0316	0.0484
60	60.0	0.684	0.636	0.367	0.0598	0.0535	0.735	0.0503	0.0629
55	62.5	0.830	0.755	0.393	0.0814	0.0810	0.851	0.0809	0.0815
50	65.0	1.010	0.897	0.418	0.1104	0.1272	0.990	0.1319	0.1057
45	67.5	1.236	1.072	0.444	0.1493	0.207	1.161	0.219	0.1373
40	70.0	1.525	1.291	0.469	0.202	0.352	1.374	0.375	0.1792
35	72.5	1.906	1.571	0.495	0.275	0.630	1.647	0.669	0.236
30	75.0	2.42	1.944	0.520	0.378	1.19	2.01	1.259	0.315
25	77.5	3.15	2.46	0.546	0.531	2.46	2.52	2.56	0.431
20	80.0	4.27	3.23	0.571	0.768	5.69	3.28	5.85	0.610



Area

$$A=(\tan\theta-\theta)R^2$$

Location of neutral axis 1-1

$$m=\left[1-\frac{\sin^2\theta\tan\theta}{3(\tan\theta-\theta)}\right]R$$

Location of neutral axis 2-2

$$n=\left[\tan\theta-\frac{\sin^2\theta\tan^2\theta}{3(\tan\theta-\theta)}\right]R$$

Location of neutral axis 4-4

$$p=\left[\sec\theta-\frac{\sin\theta\tan^2\theta}{3(\tan\theta-\theta)}\right]R$$

Moment of inertia about axis 1-1

$$I_1=\left[\frac{\sin^4\theta\tan\theta}{3}+\frac{\sin\theta\cos\theta(1+2\sin^2\theta)-\theta}{4}-\frac{\sin^4\theta\tan^2\theta}{9(\tan\theta-\theta)}\right]R^4$$

Moment of inertia about axis 2-2

$$I_2=\left[\frac{\tan\theta(\tan^2\theta+\sin^2\theta)}{6}-\frac{3\theta-\sin\theta\cos\theta(3-2\sin^2\theta)}{12}-\frac{\sin^4\theta\tan^4\theta}{9(\tan\theta-\theta)}\right]R^4$$

Moment of inertia about axis 3-3

$$I_3=\left[\frac{\sin^3\theta}{6\cos\theta}-\frac{\theta-\sin\theta\cos\theta}{4}\right]R^4$$

Moment of inertia about axis 4-4

$$I_4=\left[\frac{\sec^3\theta-\cos^3\theta}{6\sin\theta}-\frac{\theta+\sin\theta\cos\theta}{4}-\frac{\sin^2\theta\tan^4\theta}{9(\tan\theta-\theta)}\right]R^4$$

Noteworthy Patents

CONSTANT HYDROSTATIC HEAD of fuel is maintained in the reservoir of gravity-fed liquid burners by means of a snap-action constant-level device covered in patent 2,388,793. Assigned to the Automatic Products Co. by L. V. McCarty, the unit controls liquid level by a float system having unequal portions. The same difference between normal level and high level of the liquid is maintained regardless of the angular displacement of the system up to a limit of thirty degrees.

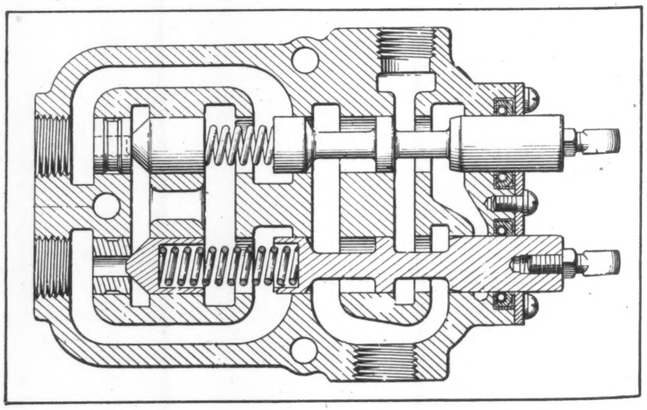
VARIATIONS IN CAPACITY from extremely high to extremely low limits is achieved easily with a novel electromagnetic pumping unit for distributing alcohol to aircraft deicers and similar devices. Covered in patent 2,393,237 by Richard T. Cornelius, a series of the pumping units simultaneously makes one stroke for each cycle of a master electromagnetic oscillating timer which can be preset as desired. Accurate metering of the liquid being pumped can be procured so that waste is obviated. In addition, design is extremely compact and light.

ANGULAR PHASE CHANGES of a great variety, comprising angular shiftings in opposite directions, are effected automatically with a drive coupling covered by patent 2,393,344 assigned to the Eisenmann Corp. by Lloyd H. Scott. The coupling is adapted for many uses, including interpositioning between the driven rotor of a magneto or distributor in the ignition system of internal-combustion engines and an engine-operated driving shaft for selectively timing the spark. Automatic advance and retarding of the spark timing can be accomplished automatically according to a preset performance-speed curve.

SEVERE TOOTH WEAR normally found with special-tooth varying-leverage differential gearing and the limited ratios of the eccentric lobulate type differential are overcome by a new design covered in patent 2,392,441. In addition, this new varying-leverage differential can be produced on standard gear-cutting machinery using standard tooth profiles. If the tractive power of a wheel attached to one side of the differential is diminished for any reason such as slipping, the power transmitted to the other wheel is periodically increased by the arrangement, thus enabling a vehicle to pull with only one wheel. This large variation in leverage transmitted to the pulling wheel occurs several times per revolution of the planet pinions. The patent is assigned to Gleason Works by Ernest Wildhaber.

CONSTANT TENSION OF A WIRE delivered to a coil winding, cable armoring, wire braiding, or like machine is assured by a new device patented under number 2,388,982 by G. L. Leithiser and assigned to General Electric Co. Considerable less weight is involved in the mechanism and as a consequence the unit can be operated at much greater speeds than previous designs.

SHOCKS ARE ELIMINATED by a hydraulic control valve covered in patent 2,392,421 recently assigned to Hydraulic Control Engineering Co. by W. T. Stephens. Valve plungers of the device are so designed as to register gradually with transverse oil passages. Oil motors, rams, double-acting hoists, or a series of single-acting hoists, may be operated under minute control without shock in starting and stopping and in addition can be slowed or locked at any desired position. Self-contained relief valves, the cracking or setting of which is dependent upon position of the valve plungers, protects the controlled mechanisms in the event of overloading or jamming.



MACHINE DESIGN'S
MATERIALS
WORK SHEET

FILING NUMBER
12.03

Nickel Silvers

ASTM Nos. B122-46T, B149-44T and B151-46T

AVAILABLE IN:

Sheet and Strip (B122-46T)
Sand Castings (B149-44T)
Rod, Bar and Wire (B151-46T)

NOMINAL ANALYSES:

	Copper	Nickel	Zinc	Lead	Tin
ASTM NO. B122-46T—SHEET AND STRIP					
Alloy No. 1	72.00	18.00	10.00	....	....
Alloy No. 2	65.00	18.00	17.00	....	....
Alloy No. 3	66.00	10.00	24.00	....	....
Alloy No. 4	55.00	18.00	27.00	....	....
Alloy No. 7	75.00	20.00	5.00	....	....
Alloy No. 8	56.50	12.00	31.50	....	....
ASTM NO. B149-44T—SAND CASTINGS					
Alloy No. 10A	57.00	12.00	20.00	9.00	2.00
Alloy No. 11A	64.00	20.00	8.00	4.00	4.00
Alloy No. 11B	66.50	25.00	2.00	1.50	5.00
ASTM NO. B151-46T—ROD, BAR AND WIRE					
Alloy A	65.00	18.00	17.00	....	....
Alloy B	55.00	18.00	27.00	....	....
Alloy C	62.00	18.00	19.00	1.00	....

PROPERTIES

TENSILE STRENGTH

(*psi*)

			Minimum	Maximum
Alloy No. 1				
	Sheet and Strip,	quarter hard	56,000	69,000
		half hard	63,000	75,000
		hard	73,000	84,000
		extra hard	79,000	90,000
Alloy No. 2				
	Sheet and Strip,	quarter hard	58,000	72,000
		half hard	66,000	80,000
		hard	78,000	91,000
		extra hard	86,000	98,000
		spring	90,000	101,000
Alloy No. 3				
	Sheet and Strip,	quarter hard	56,000	73,000
		half hard	67,000	82,000
		hard	80,000	94,000
		extra hard	89,000	102,000
		spring	95,000	108,000
Alloy No. 4				
	Sheet and Strip,	quarter hard	69,000	87,000
		half hard	78,000	95,000
		hard	92,000	107,000
		extra hard	102,000	115,000
		spring	108,000	120,000
Alloy No. 7				
	Sheet and Strip,	quarter hard	54,000	68,000
		half hard	63,000	77,000
		hard	73,000	85,000
		extra hard	78,000	89,000
		spring	82,000	91,000
Alloy No. 8				
	Sheet and Strip,	quarter hard	65.000	81,000
		half hard	75,000	91,000
		hard	90,000	105,000
		extra hard	101,000	114,000
		spring	109.000	122,000
Alloy 10A, as cast			30,000	.....
Alloy 11A, as cast			30,000	.....
Alloy 11B, as cast			45,000	.....
Alloy A				
	Wire 0.020 to 0.250-in. diam,	rivet temper	60,000	80,000
		hard temper	98,000	110,000
		spring temper	112,000	125,000
	Rod 0.100 to 0.500-in. diam,	rivet temper	60,000	80,000
		light-drawn temper	65,000	85,000
		hard temper	90,000	100,000
		spring temper	100,000	115,000
Alloy B				
	Wire 0.020 to 0.250-in. diam,	rivet temper	62,000	85,000
		hard temper	115,000	130,000
		spring temper	130,000	150,000
	Rod 0.100 to 0.500-in. diam,	rivet temper	60,000	85,000
		light-drawn temper	70,000	90,000
		hard temper	105,000	120.000
		spring temper	118,000	140,000

MACHINE DESIGN is pleased to acknowledge the collaboration of the following companies in this presentation: The American Brass Co.; Chase Brass and Copper Co.; The International Nickel Co. Inc.; Revere Copper & Brass Inc.; Scovill Manufacturing Co.; and The Seymour Manufacturing Co.

TENSILE STRENGTH (*cont'd*)

Alloy C	Minimum	Maximum
Wire 0.020 to 0.250-in. diam, rivet temper	60,000	72,000
hard temper	70,000	85,000
Rod 0.100 to 0.500-in. diam, rivet temper	60,000	70,000
hard temper	70,000	.....

YIELD STRENGTH

(*0.5% elongation under load, psi, average*)

	Hard Temper*	Soft Temper
Alloy No. 1, sheet and strip	83,500†	28,000
Alloy No. 2, sheet and strip	70,000	30,000
Alloy A, rod and bar	60,000	25,000
wire	90,000	25,000
Alloy No. 3, sheet and strip	70,000	28,000
Alloy No. 4, sheet and strip	78,000	30,000
Alloy B, rod and bar	60,000	22,000
Alloy No. 7, sheet and strip	55,000	18,000
	As Cast	
Alloy No. 10A, sand castings	15,000 min	
Alloy No. 11A, sand castings	17,000 min	
Alloy No. 11B, sand castings	22,000 min	

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* Hard temper values are for sheet reduced 4 B & S gage numbers in thickness by cold rolling and for rod bar and wire of commercial hard-drawn temper.

† Reduced 6 B & S gage numbers.

ELONGATION IN 2 INCHES

(*nominal, per cent*)

	Hard Temper*	Soft Temper
Alloy No. 1, sheet and strip	3§	36
Alloy No. 2, sheet and strip	4	40
Alloy A, rod and bar	20	42
wire	1†	40†
Alloy No. 3, sheet and strip	7	42
Alloy No. 4, sheet and strip	4	45
Alloy B, rod and bar	20	45
wire	1†	40†
Alloy No. 7, sheet and strip	5	35
	As Cast	
Alloy 10A, sand castings	8 min	
Alloy 11A, sand castings	8 min	
Alloy 11B, sand castings	15 min	

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* Hard temper values are for sheet reduced 4 B & S gage numbers in thickness by cold-rolling and for rod, bar and wire of commercial hard-drawn temper.

§ Reduced 6 B & S gage numbers.

† Elongation of wire, per cent in 10 inches.

CHARACTERISTICS

Nickel silvers—alloys of copper, nickel and zinc—offer corrosion resistance better than that of the common brasses. have good mechanical properties, are moderate in cost, have reasonably good fabricating properties, and are available in a wide variety of cast, rolled and extruded shapes. Alloys containing 18 per cent nickel are most commonly used. They possess excellent ductility and as a result can be readily drawn, stamped, cold forged, coined, spun, etc. Nonleaded nickel silvers are excellent for resistance welding, silver-alloy brazing and soft soldering. Stock usually is cold rolled and annealed, hot work being recommended only when the zinc content is around 40 per cent or less than about 10 per cent. Hardness and strength are added to nickel silvers by cold working, and the harder tempers, particularly of Alloy No. 4 in strip and Alloy B in wire, are excellent spring materials. Color of the nickel silvers varies from light pink to silvery white, nickel being the most important element in developing whiteness. The 5 per cent nickel alloys have a pink cast, the 8 to 12 per cent alloys have a light yellow cast, the 15 per cent alloys have a pale green cast, and the 18 per cent alloys are, for all practical purposes, true white.

APPLICATIONS

Alloy No. 1: This is a deep-drawing nickel silver. It may be used in difficult forming operations where the more common Alloy No. 2 fails to meet requirements.

Alloy No. 2: For deep-drawn parts, formed and extruded shapes. Typical applications are: Truss wire, zippers, camera parts, name plates, radio dials, rivets, screws, marine and automotive trim, and springs.

Alloy No. 3: For stamped and embossed parts and decorative trim. In general uses are similar to those of Alloy No. 2.

Alloy No. 4: Excellent for springs. Other uses are resistance wire and extruded shapes.

Alloy No. 7: Sometimes used for condenser tubes and condenser sheets.

Alloy No. 8: Applications are similar to those of Alloy No. 4.

Alloy A: Good for springs. The rod stock is excellent for turned parts which must have good appearance plus good strength.

Alloy B: Excellent for springs and resistance wire.

Alloy C: Excellent for such applications as gears, pinions and watch parts, screw machine parts, binocular and camera parts and machine screws.

FABRICATION

MACHINABILITY:

Leaded nickel silver (Alloy C) has a machinability rating of about 50 as compared to 100 for free-cutting yellow brass. Alloys A and B (nonleaded) have ratings of approximately 20. Chips produced when machining rod and bar of Alloys A and B generally are long, tough and stringy. Surface speed for turning Alloy C with a properly formed high-speed steel tool ranges

PHYSICAL CONSTANTS

	Melting Point (deg C)	Young's Modulus (psi)	Weight (lb per cu in.)	Average Coef. Linear Thermal Expansion (per deg F, 77 to 572 F)	Electrical Conductivity (% of IACS) at 68 F*	Thermal Conductivity (Btu/sq ft /ft/hr/deg F (68 F)
Alloy No. 2, sheet and strip	1110	18,000,000	0.316	0.0000090	6.0	19
Alloy A, rod and bar	1110	18,000,000	0.316	0.0000090	6.0	19
wire	1110	18,000,000	0.316	0.0000090	6.0	19
Alloy No. 3, sheet and strip	1010	17,000,000	0.313	0.0000091	8.4	27
Alloy No. 4, sheet and strip	1055	18,000,000	0.314	....	5.3	17
Alloy B, rod and bar	1055	18,000,000	0.314	....	5.3	17
wire	1055	18,000,000	0.314	....	5.3	17
Alloy No. 7, sheet and strip	1150	19,000,000	0.320	0.0000091	6.1	22

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* Electrical conductivity values are for soft annealed metal. In hard tempers conductivity is slightly lower.

ROCKWELL HARDNESS

(values not intended for specification)

		G Scale*		B Scale*		Superficial† 30-T Scale	
		Min.	Max.	Min.	Max.	Min.	Max.
Alloy No. 1							
Sheet and Strip,	quarter hard	20	47	66	80	60	70
	half hard	38	53	75	84	67	73
	hard	51	61	83	88	72	75
	extra hard	57	65	86	90	74	76
Alloy No. 2							
Sheet and Strip,	quarter hard	..	..	50	75	49	67
	half hard	..	..	68	82	62	72
	hard	..	..	80	90	70	76
	extra hard	..	..	87	94	74	79
	spring	..	..	89	96	75	80
Alloy No. 3							
Sheet and Strip,	quarter hard	..	..	51	80	50	70
	half hard	..	..	72	87	65	75
	hard	..	..	85	92	73	78
	extra hard	..	..	90	94	76	79
	spring	..	..	92	96	77	80
Alloy No. 4							
Sheet and Strip,	quarter hard	23	62	70	88	63	75
	half hard	51	69	81	92	71	78
	hard	67	76	90	96	76	80
	extra hard	73	80	95	99	79	82
	spring	77	83	97	100	80	..
Alloy No. 7							
Sheet and Strip,	quarter hard	..	..	62	78	58	69
	half hard	..	..	73	84	65	73
	hard	..	..	81	89	71	76
	extra hard	..	..	85	91	73	77
	spring	..	..	87	92	74	78
Alloy No. 8							
Sheet and Strip,	quarter hard	..	..	61	85	57	74
	half hard	..	..	78	91	69	77
	hard	..	..	90	95	76	79
	extra hard	..	..	94	98	79	81
	spring	..	..	97	100	80	..

* G and B scale values apply to metal 0.020-in. and over in thickness.
† 30-T scale values apply to metal 0.012-in. and over in thickness.

from 150 to 300 feet per minute. For Alloys A and B, this is reduced by about 50 per cent. If carbide-tipped tools are employed, surface speed for rough-turning Alloy C ranges from 300 to 500 feet per minute with finish-turning being effected at surface speeds of 400 to 600 feet per minute. These speeds are lowered slightly for Alloys A and B.

DRILLING:

For the nonleaded alloys, high-spiral drills having a helix angle of approximately 40 degrees are best. However, where production volume does not warrant the use of special drills, standard carbon or high-speed steel drills, properly ground, are satisfactory. While these alloys occasionally are drilled dry, a suitable lubricant is used wherever feasible. In general, the leaded alloys are drilled (with highspeed steel drills) at speeds ranging from 75 to 250 feet per minute. The nonleaded alloys take drilling speeds of 50 to 125 feet per minute. Feeds per revolution for all alloys, in drill sizes from ⅛ to ¾-inch, range from 0.003 to 0.020-inch, the lighter feeds, of course, being used with the smaller diameter drills. If carbon steel drills are used, the suggested speeds are reduced by about one-half.

REAMING:

Standard straight-flute reamers have a tendency to chatter on some types of work. To overcome chatter and produce a smoother finish, standard spiral-flute reamers with helix angle of from 7 to 12 degrees are recommended. Left-hand spiral, right-hand cut reamers give excellent results for either straight or tapered holes. They cut freely and do not pull into the work. To avoid burnishing action which results in undersize holes and excessive wear of the reamer, sufficient stock should be left for reaming. This is particularly important where wall thickness is small in relation to hole diameter. Leaded alloys generally are reamed (with high-speed steel spiral reamers) at cutting speeds of 75 to 150 feet per minute. Nonleaded alloys commonly ream at speeds of 60 to 90 feet per minute. Reaming feeds ordinarily are two to three times those used for drilling.

TAPPING:

Wherever permissible, a tap-drill size that will result in a 75 to 80 per cent depth of tapped thread should be specified. Cleaner threads result, fewer taps are broken and less power is required than when tapping full-depth threads. For machine tapping, high-speed steel taps with ground threads are desirable. In instances where the threads have a tendency to tear as the tap is being backed out, a rake angle ground on both sides of the flute usually will overcome this difficulty. For machine tapping the leaded alloys, regular two, three or four-fluted taps with narrow lands, deep, polished flutes and a two or three-thread chamfer usually are satisfactory. For the nonleaded alloys spiral-pointed taps with two or three flutes are preferred for tapping through holes or blind holes drilled sufficiently deep for chip clearance. An ample supply of cutting fluid should be used on all tapping operations. Using high-speed steel taps, for fine to moderate-pitch threads, tapping speed for the leaded alloys range from 60 to 150 feet per minute. For the nonleaded alloys, tapping speeds range from 30 to 60 feet per minute.

HOT AND COLD WORKING:

Alloys Nos. 1 and 2 are excellent for cold working operations but poor for hot working. Under cold working, Alloy No. 1 is somewhat more ductile than No. 2. Annealing temperature for Alloy No. 2 ranges from 1100 to 1500 F. Alloy No. 3 is similar in cold working properties to No. 2. Alloy No. 4 is good for cold working but poor for hot working. Alloys A and B have working properties similar to those of Alloys Nos. 2 and 4 respectively. Alloy No. 7 for cold working operations is similar to No. 2 except that it does not work harden as rapidly. Alloy No. 7 can be used for certain types of hot working. Alloy No. 8 is approximately the equivalent of No. 4 in cold working properties. Alloy C is not suitable for hot working and is very limited in cold working because its lead content reduces ductility.

STAMPING, FORMING AND DRAWING:

All of the nickel silvers except Alloy C are well adapted to stamping and forming operations because, in general, they possess excellent ductility and strength. Since the No. 2 alloy generally is used where appearance is a major factor and buffing is required, close control of grain size is important. For drawing work a grain size of 0.020 to 0.040-mm is considered optimum. In stamping, forming and drawing, nickel silver handles somewhat like 80-20 brass. From the standpoint of workability a typical soft or light anneal reacts the same on nickel silvers as on 80-20 brass except that grain growth is not as great for the same anneal.

SOLDERING, BRAZING AND WELDING:

Nickel silvers, providing they are nonleaded, can be oxy-acetylene welded, soft soldered, or silver-alloy brazed and are also suitable for spot and seam resistance welding. All of the alloys, however, whether leaded or nonleaded, are considered unsuitable for carbon arc welding. The table gives general suitability ratings of the various alloys to soldering, brazing and welding processes.

CORROSION RESISTANCE

Nickel silvers resist corrosion in all types of atmospheres, in natural and industrial waters, in sea water, and in many of the mineral and organic acids. Resistance to corrosion increases as the percentage of nickel or copper is increased. The table gives general corrosion resistance ratings of the various alloys.

SUITABILITY FOR SOLDERING, BRAZING AND WELDING

Alloy (ASTM Spec. and Alloy No.)	Soft Soldering	Silver-Alloy Brazing	Oxy-acetylene Welding	Carbon Arc Welding	Resistance Welding (Spt. & Sm.)
B122, Alloy No. 1	Excellent	Excellent	Good	Poor	Good
Alloy No. 2	Excellent	Excellent	Good	Poor	Good
Alloy No. 3	Excellent	Excellent	Good	Poor	Good
Alloy No. 4	Excellent	Excellent	Good	Poor	Good
Alloy No. 7	Excellent	Excellent	Good	Poor	Good
Alloy No. 8	Excellent	Excellent	Good	Poor	Good
B149, Alloy No. 10A	Excellent	Good	Poor	Poor	Poor
Alloy No. 11A	Excellent	Good	Poor	Poor	Poor
Alloy No. 11B	Excellent	Good	Poor	Poor	Fair
B151, Alloy A	Excellent	Excellent	Good	Poor	Good
Alloy B	Excellent	Excellent	Good	Poor	Good
Alloy C	Excellent	Good	Poor	Poor	Fair

APPROXIMATE CORROSION RESISTANCE RATINGS

	General Outdoor Air			Specific Industrial Atmospheres (Wet)				
Alloy	Rural	Urban	Marine	Ammonia	Hydrogen Sulfide	Hydrogen Chloride	Sulfur Dioxide	Chlorine
1	A	A	A	E	C–	C+	B	C+
2	A	A	A	E	C–	C+	B	C+
3	A	B	A	E	C	E	B–	E
4	A	B	A	E	C+	E	B–	E
7	A	A–	A	E	C–	C+	B	C+
8	A	B	A	E	C+	E	C+	E
10A	A	B	A	E	C+	C+	B–	C+
11A	A	A–	A	E	C–	C+	B	C+
11B	A	A–	A	E	C–	C+	B	C+
A	(Same as for No. 2)							
B	(Same as for No. 4)							
C	A	A–	A	E	C–	C+	B	C+

A—Practically complete resistance, or alloy is best of materials within its class.

B—Good resistance, as proved by being in common use. May replace materials given A rating to secure some other advantage.

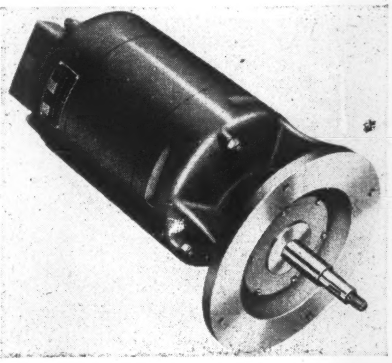
C—Adequate resistance under favorable conditions which should be investigated beforehand.

E—Poor resistance—use only if no better material is available.

new parts and materials

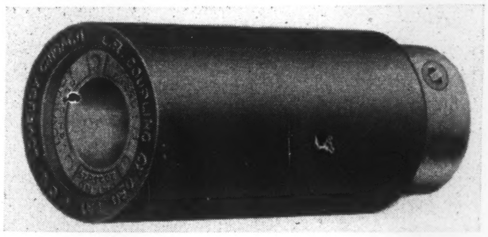
Small Gear Motor

ANNOUNCED by the Electrical Engineering & Manufacturing Corp., 4606 W. Jefferson Blvd., Los Angeles, a new 5-hp, 8000-rpm motor was developed for limited space application. The motor utilizes commercially available 3-phase, 60-cycle, 220-volt power. Essentially a fan-cooled, open-type, two-pole 3600-rpm motor, the output speed is stepped up by a single-reduction helical gear train in a sealed gear box. This design is said to permit a smaller and more compact motor.



Flexible Coupling

FEATURING one-piece construction, a new coupling having high flexibility has been developed by the Lovejoy Flexible Coupling Co., 5009 W. Lake St., Chicago 44. Known as type CX Double-flex, the coupling engages L-R jaws on the driven unit. Advantages claimed for the coupling are quick assembly, no metal-to-metal contact, and deep center-hole. Six sizes are available.

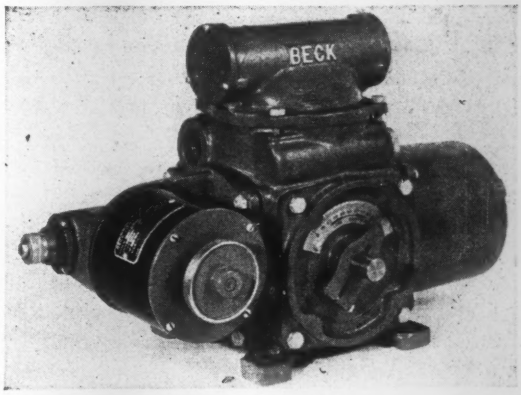


Spur-Curve Conveyor

NEWLY-DESIGNED by the Rapids-Standard Company, Inc., 308 Peoples National Bank Bldg., Grand Rapids 2, Michigan, a wheel-conveyor spur is used with conveyor installations. The selecting spur-curve permits conveyor users the choice of directing flow of materials either straight-line or around the spur to a line running at right-angle to the main line. Manual operation of a lever and cam mechanism raises a steel switch-plate on which is positioned a set of independently-mounted conveyor wheels. These wheels, when projecting above the level of the wheels on the curve, allow packages to roll on the main line. Moving the operating lever down lowers the switch-plate wheels below the level of curve-wheels diverting the load around the curve to the spur line.

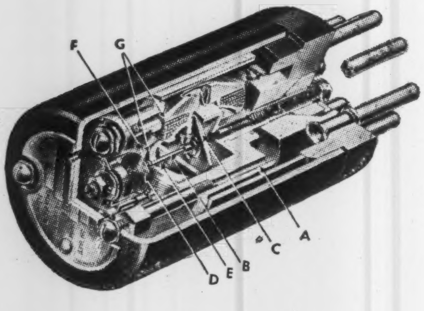
Automatic-Control Actuator

MAKING POSSIBLE close control of rheostats, valves, and similar devices under rapidly changing loads, and permitting operation at maximum sensitivity, the Beck Mechanism has been announced by the Harold Beck Co., 3644 North Second St., Philadelphia 40. The triple function control system is based on three control actions. The first is proportional to and opposes any change of the controlled condition within the throttling range. The second is proportional to the action of the first and is introduced to the system as fast and not faster than it can be absorbed. The third action consists of an impulse that is periodically introduced when the system is off the control point, to move the regulating device in the proper direction and to restore the system to the control point. Driven by a slow-speed, high-torque control motor, the mechanism is used for control of furnaces, safety circuits, etc.



Sensitive Magnetic Relay

USEFUL for operation on currents of thermocouple and photo-cell magnitudes, and in equipment where compactness, lightweight, and dependability under vibration are of primary importance, a new relay is announced by the Instrument Division of Thomas A. Edison, Inc., West Orange, New Jersey. Known as Magnetic Relay Model 103, the relay is an inversion of the d'Arsonval galvanometer type movement in that the permanent magnet swings and the coils are stationary. Normally requiring 10 microwatts for operating power, the contact will handle 1/3-amp in a noninductive-load circuit. Either single-pole single-throw, or single-pole double-throw switching may be provided. Mounted on a standard, small, seven-pin radio-tube base, and only 2¼ inches in height, the unit is said to be particularly useful in balanced circuits as a polarized relay and in applications requiring pull-in and drop-out at essentially the same current or voltage.

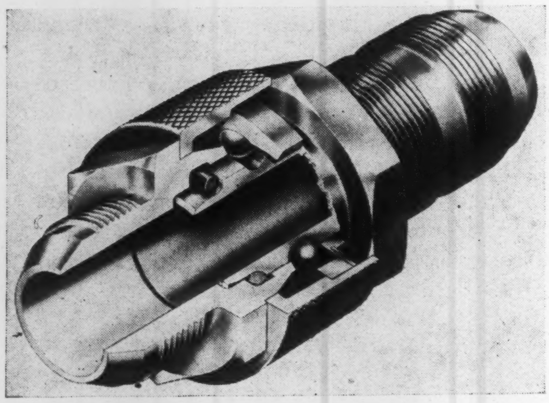


New Aluminum Alloy

RECENTLY announced by the Reynolds Metals Company, 2500 South Third Street, Louisville 1, is a new free-machining aluminum alloy of particular usefulness for screw machine parts. Known as 'R317-T', it is said to have been machined at speeds up to three times the normal speeds used with free-cutting steel screw stock.

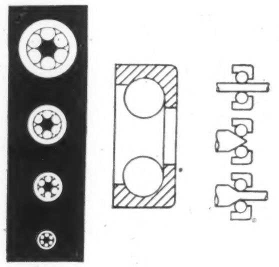
New Quick Couplings

ESPECIALLY designed for use on hoses and lines operating under pressure, a new coupling has been announced by the Roylyn Mechanical Laboratory, 8928 Santa Monica Boulevard, Los Angeles 45. Based on the inclined plane and wheel principle, the coupling employs three major parts: The cam ring, ball cage, and nipple. Rotating the cam collar forces the steel balls into a groove in the nipple, thus forcing the halves together. The gasket provides a positive seal as well as providing a spring force necessary to the lock operation. A slight shoulder on the cam assures a positive lock, application of more pressure tightens it, and only the cam collar can unlock it. Available in aluminum, brass, or alloy steel to suit various conditions, the new coupling is said to be particularly adapted for hydraulic and pneumatic lines running from pressurized tanks.



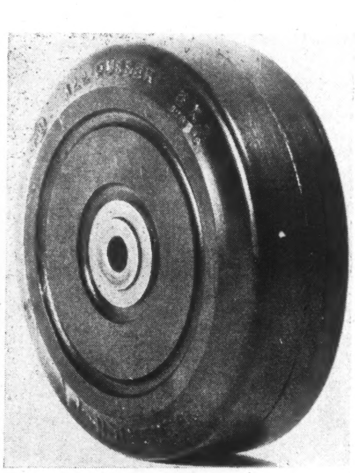
Angular-Contact Ball Bearings

ANNOUNCED by the Miniature Precision Bearings Co., Keene, N. H., are new angular contact miniature bearings. Used to take radial or thrust loads or a combination of both, the bearings function safely and effectively under unusually heavy loads and high speeds for their weight and size, yet respond efficiently in light service. Made of chrome alloy bearing steel to precision tolerance, no separator is required in the bearing since the balls are fully self-retained.



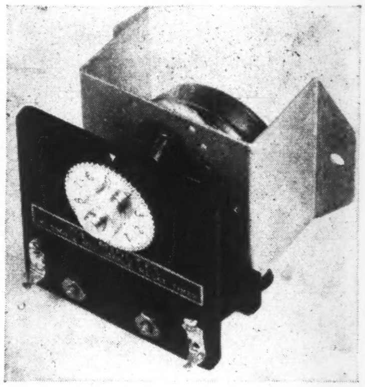
Industrial Wheel

CONSTRUCTED with a metal bearing-sleeve molded integrally in a hard rubber core is a new wheel announced by the B. F. Goodrich Co., Akron. Supplementing the company's vulcanized-on tire-to-metal wheel, these wheels have capacity ratings equal to vulcanized-on tires and metal wheels of the same size. Impact load resistance is somewhat lower and the wheels are not recommended for extremely rough usage. The new wheel is especially suggested for uses where corrosive agents detrimental to metals or the rubber-to-metal bond are encountered.



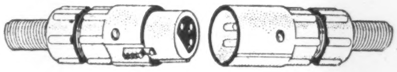
Reset Timer

HAVING delay times from one second to ten minutes, a new low-price adjustable reset timer has been announced by the Haydon Mfg. Co., Forestville, Conn. Said to meet most time delay reset requirements, the timer has an overall size of 3⅜ x 2⅞ x 2⅞-inches including the dial and adjusting knob. The motor features a magnetically controlled clutch that automatically engages the gear train when energized and disengages when de-energized. When the current is turned off, the drive shaft returns to its starting position by spring action. The motor is furnished with one-way friction to absorb the shock to the gear train at the end of the return travel. The timer switch, normally-open or closed, is rated at 10 amperes, 125 volts.



Electrical Connector

DESIGNED to meet the demand for a small multi-contact electrical connector for low-level sound uses, Cannon Electric Development Co., 3209 Humboldt St., Los Angeles 31, has announced its type XL series of plugs and receptacles. The die-cast zinc shell, ⅝-in. in diameter and 2 3/32-in. long, is provided with polarizing, and cable-release means. Having three 15-ampere silverplated brass contacts and a latch-lock device, the connectors will accommodate No. 14 Brown & Sharpe stranded wire.



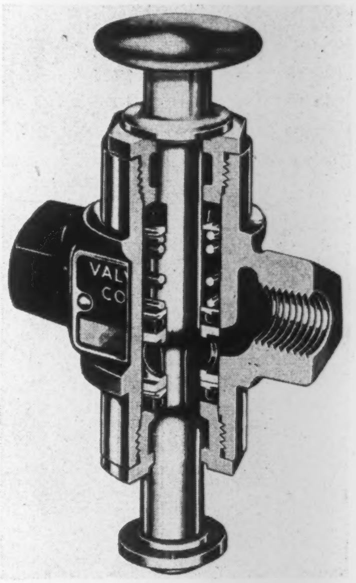
Aluminum Structural Material

LIGHTWEIGHT structural material composed of two sheets of aluminum bonded on either side of a cellulosic core, is announced by the Reynolds Metals Co., 2500 South Third St., Louisville 1. Known as Reynalite, the material, which can be attached with the usual type of fasteners such as nails or screws and may be cut with metal or woodworking equipment, is recommended for structural units in vehicles or airplanes.

Tape-Tension Pulley

DEVELOPED by SKF Industries, Inc., Front Street & Erie Avenue, Philadelphia, a new tape-tension pulley is mountable directly on cotton-spinning frames. Four inches in diameter, the pulley consists of a plastic shell with aluminum shield, mounted on a deep-groove ball-bearing having a stationary shaft. Fitting present spinning-frame brackets, plastic blocks of the same external dimensions as the wood bearings support the pulley shaft. Power saving and a reduction in spindle shutdowns are said to accrue from use of the new unit.

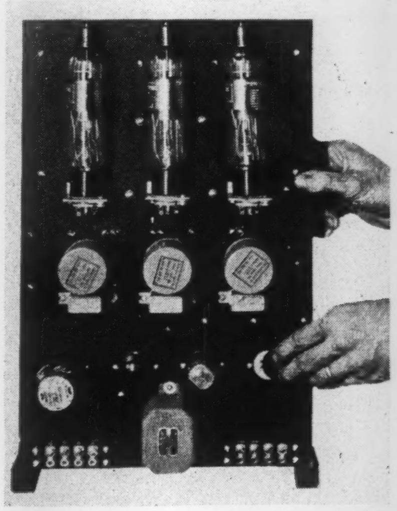
Air Valves



AIR-VALVES operating upon the sliding-plunger principle have been announced by the Valvair Corp., 454 Morgan Avenue, Akron 11, Ohio. Handling pressures up to 200 psi at temperatures up to 120 F, the valves employ sliding stems moving through series of specially designed packings which seal the air in on or off positions without use of metal seats. Available in a wide range of combinations, the valves are so designed that the valve area is equivalent to standard pipe sizes, eliminating restriction. Special valves may be obtained on inquiry.

Electronic Variable-Speed Drive

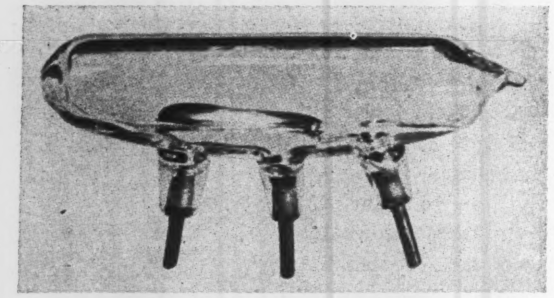
CONTROLLING SPEED electronically, a new variable-speed drive is being marketed under the tradename Servotron by Submarine Signal Co., 160 State St., Boston 9.



Although similar to other variable-speed drives supplied by the company, the new model embodies new principles and features. It operates on alternating current and through an electronic controller runs a direct-current motor at speeds which are infinitely variable within the motor's speed and load capacity. Uniform torque is maintained over the entire speed range. The Servotron also has instantanious dynamic braking and instant reversal without speed overrun. Within the coming year the company expects to have available a complete line of drives.

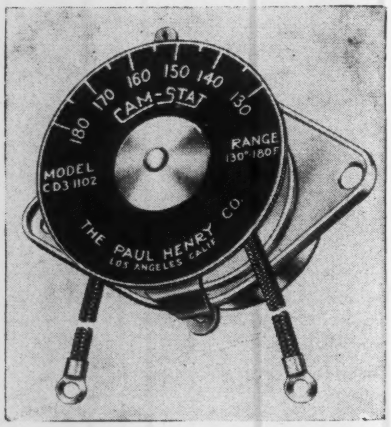
Mercury Switch

MANUFACTURED by the Victoreen Instrument Co., 3800 Perkins Avenue, Cleveland 14, is a new three-contact mercury switch. Known as Vimerc, the switch is approximately 2½ inches long, and 1⅜ inches in full height. It is supplied with 4½-in. flexible contacts as standard equipment. The unit is designed with a straight top to simplify mounting and the well-designed mercury well is said to permit smooth mercury flow and positive mercury-to-mercury contact. Of a shorting type, the switch is designed to operate at 12 amperes, 250 volts ac or dc.



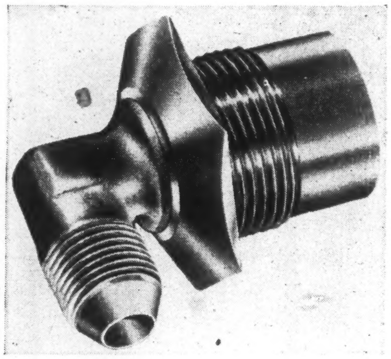
Adjustable Temperature Control

ADJUSTABLE CALIBRATED temperature control recently introduced by Paul Henry Co., 2037 South La Cienga, Los Angeles 34, is available in a wide choice of adjustable ranges between −50 and + 600 F, with differentials as low as 1 F. It may be clamped on the tank or the element may be immersed in water. A wide variety of mountings is available for adapting the unit to the control of air, gas, liquid or solids. The unit has double-break snap-action contacts, with ratings of 12 amperes, 115 volts alternating current, or 28 volts direct current; in single-pole single-throw, single-pole double-throw, or single-pole double-throw independent circuit.



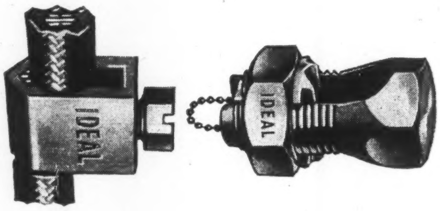
Swivel Pipe Coupling

BALL-BEARING type coupling for fluid pressures to 3000 psi has been announced by the Snyder Sales Corp., 5225 Wilshire Blvd., Los Angeles 36. Swiveling through 360 degrees, the coupling utilizes a combination of multiple synthetic packings and metallic seals. A double row of ball bearings offers only 9.6 inch-pound torque at 3000 psi internal fluid pressure. The unit is available in a variety of connections, and tube sizes from ⅛ to 1 inch.



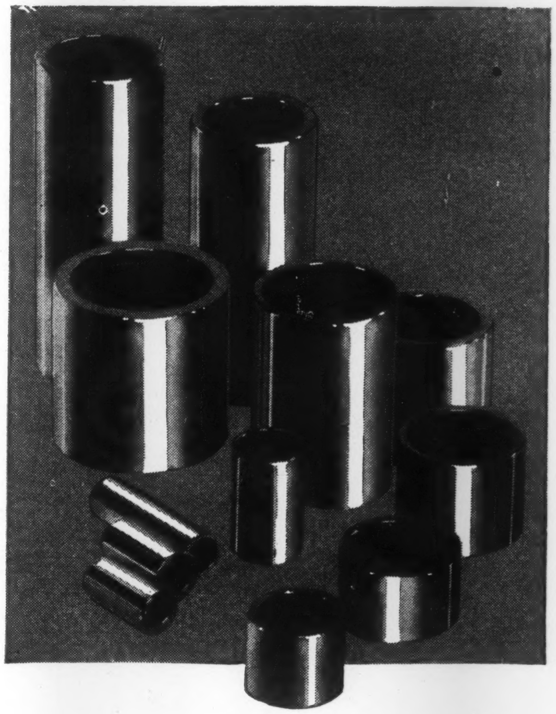
Wire Connector

IDEAL Commutator Dresser Co., 1059 Park Avenue, Sycamore, Ill., has recently announced a new line of split-bolt connectors and service-entrance connectors. The split-bolt connectors are available in two types—one-piece and two-piece—with small or large heads. They are also available in bronze, brass, or aluminum. Uniform contact surfaces are said to assure maximum conductivity and low resistance. A wide range of sizes accommodate all solid and stranded wire from No. 6 to 1,000,000 cir mils. The service-entrance connectors are made from cold-drawn copper with the screws made from Everdur. There are five sizes ranging from No. 12 solid.



Miniature Capacitors

MIDGET capacitors in the unity micro-microfarad range have been announced by the Electronic Components Division of the Stackpole Carbon Co., St. Marys, Pa. Designated type GA-Midget, the capacitors have been designed to eliminate the improved makeshift of twisted wires. They are inexpensive, and possess the attributes of



Now IS THE TIME TO

Standardize

The trend in manufacturing circles today is toward STANDARDIZATION—away from specials. This is particularly true of Sleeve Type Bearings. The designer of tomorrow's machines has a golden opportunity now to combine economy with efficiency by utilizing Johnson G. P. Standard Stock Bearings.

From our list of over 850 stock sizes, the designer can secure at least 90% of his requirements without delay. Every bearing is precision finished to standard tolerances, ready for immediate installation. Large production runs provide a low unit cost and every bearing is cast from the highest quality bronze alloy available.

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JOHNSON
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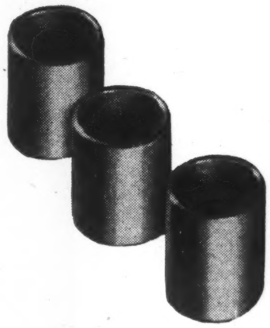
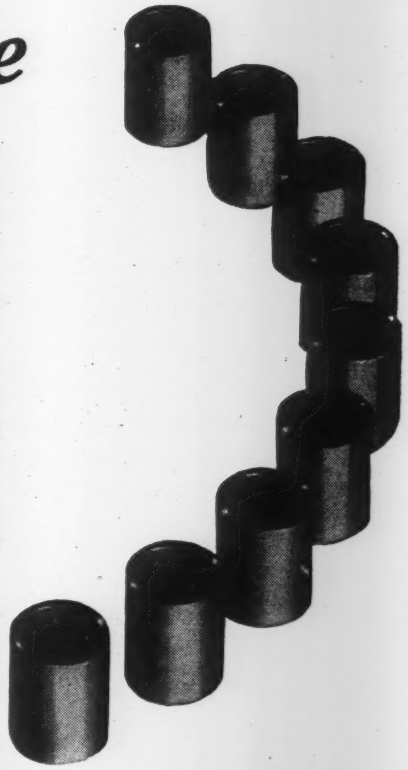
GENERAL PURPOSE





JOHNSON BRONZE
SLEEVE BEARING HEADQUARTERS

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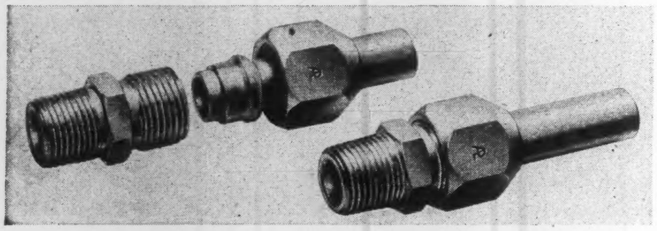
CAMBRIDGE, MASS. CHICAGO
CINCINNATI CLEVELAND
DALLAS DETROIT KANSAS CITY

LOS ANGELES MINNEAPOLIS
NEWARK NEW YORK
PHILADELPHIA PITTSBURGH
SAN FRANCISCO ST. LOUIS SEATTLE

stability, high Q and breakdown voltage, and ease of installation. Finding use for capacity coupling and other applications the condensers are available in ratings from 0.68 to 4.7 $\mu\mu$f, with a tolerance of plus or minus 20 per cent.

Tube Fitting

DEVELOPED for use in joining all types of metal tubing in hydraulic and fluid-conveying systems, a new flareless fitting is offered, by the Parker Appliance Co., 17325 Euclid Avenue, Cleveland. Known as Ferulok, the fitting incorporates a steel ferrule which automatically cuts a shoulder in the tubing and requires no special tools, brazing or soldering. Wedge action of a tightening nut forces down the forward and rear edges of a confined ferrule, the compression of which acts as a fluid seal. The fitting is said to be particularly useful in high-pressure applications and in installations where thick-wall tubing is used.



Engineering Dept Equipment

New Autotransformers

VARIAC
OFF
ON

KNOWN as type V-5, a new series of 5-amp Variacs replacing type 200-C is announced by General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass. 25 per cent increase in kva per pound has been realized from this model. Available in several models with or without case and terminal box cover, the new Vari-ac is rated at 5-amp for 115-v service. 230-volt models rated at 2 amp, 2.5 amp, max. Voltage output can be varied from 0 to 17 per cent above line voltage. Aluminum structural parts are used

All-Purpose Pyrometer

ANNOUNCED by the Pyrometer Instrument Co., 103 Lafayette St., New York 13, a new surface pyrometer is designed to meet the ever increasing necessities for precision, accuracy, durability, and ease of operation. It is completely self-contained, portable, compact, and quick acting. Constructed in a shock, moisture and dust-proof shielded-steel housing, it is immune to external magnetic influences. A 4¾-inch diameter indicator dial makes reading quick and accurate. Choice of eight different thermocouples and two types of extension arms, all instantly interchangeable without adjustment or re-calibration, together with a selection of five different temperature ranges of 0-300 F to 0-1200 F, makes this instrument suited to a wide range of problems.

Translucent Photographic Papers

THREE NEW industrial photographic papers which will speed the production of paper positives from engineering drawings and enable high-quality blueprints to be produced, have just been announced by the Eastman Kodak Co., Rochester 4, N. Y. Known as Reflex Copy TXA, Linagraph Ortho TXA, and Linagraph Blue Sensitive TXA, the papers are translucent, light in weight, and have a high wet and dry strength. They can thus be used for filing purposes, or for binding into books. Because of the high degree of translucence, it is said that these papers may be used in place of film negatives where rapid printing time is necessary.

Miniature Magnifier

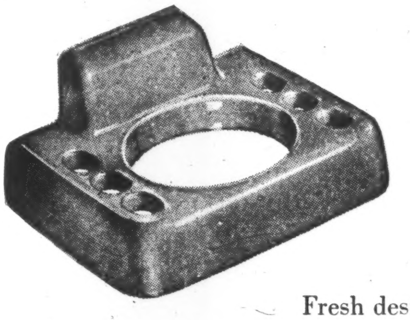
MINIATURE magnifier with a power of 3½-x has been announced by the Edroy Products Company, 480 Lexington Avenue, New York 17. Measuring 1¼-in. wide and 2¼-in. long and weighing three-quarters of an ounce, the square-lens, wide-field glass is said to have excellent resolving power. A plano-convex lens, it is mounted in Lumarith and folds into a handle when the instrument is not in use.

Vacuum-Tube Voltmeter

A NEW high-sensitivity vacuum-tube voltmeter designed especially for laboratory and industrial electronic testing has been announced by the Meter and Instrument Div. of the General Electric Co., Schenectady, N. Y. Iden-

STYRON
DOW POLYSTYRENE
THE NAME YOU CAN DEPEND ON IN PLASTICS

A material step toward home beauty



Fresh design! Enduring, living color! Styron blends these qualities with maximum effectiveness for home interiors—and gives maximum service, too! In bathroom fixtures, this Dow plastic permits design that makes for simple installation, ready removal and quick cleaning. Styron's lightness makes it easy to handle. Its smoothness and warmth give it a pleasant touch. And its solid dependability means extra life and satisfaction. Water won't harm Styron. Nor will alkalies from soaps, nor acids. You'll find that Styron serves long and well—and brilliantly! You can *depend* on Styron for permanent beauty and new design in satisfying products in the home.

let's work it out together

Success in plastics is best measured in end products. It calls for combined efforts of manufacturers, designers, fabricators, raw material producers. Dow is ready to do its part. Save time and money—call on Dow and get the most out of plastics.

PRESENT AND POTENTIAL USES—Lighting fixtures and displays; insulators; hydrometers; battery cases; funnels; bottles; closures; food handling equipment; pharmaceutical, cosmetic, and jewelry containers; jewelry; advertising items; refrigerator parts; pens, pencils; chemical apparatus; lenses; decorative objects and trim.

PROPERTIES AND ADVANTAGES—Beautiful, clear, translucent; "pipes" light through rod around corners, etc.; resistant to acids and many alkalies; stable at low temperatures; excellent electrical properties; broad color range; low specific gravity, providing more moldings per pound; low water absorption.

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PLASTICS
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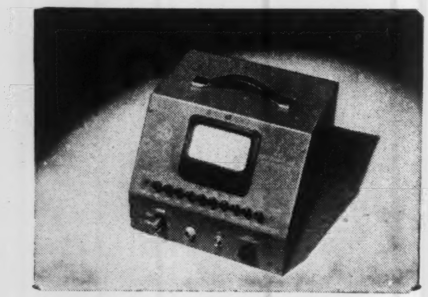
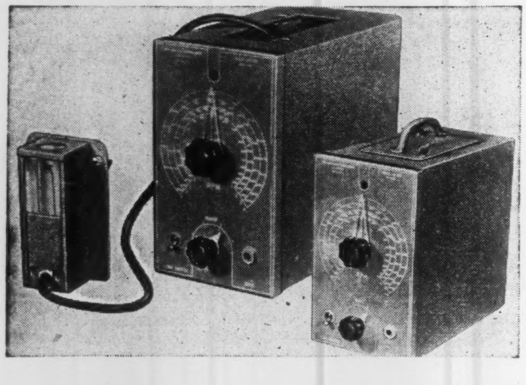
tified as Type AA-1, this new voltmeter has ten calibrated voltage ranges, the lowest being 10 millivolts full scale for readings as low as 1 millivolt, and the highest 300 volts. For frequencies between 15 cycles and 500 kc, the accuracy is ± 3 per cent; and between 500 kc and 1 megacycle it is ± 5 per cent. The instrument can be used for a range of between 10 cycles and 1.5 megacycles. Also it is graduated in decibels and covers a range of minus 65 to plus 45. A ten-position push button switch mounted on the front panel allows any working range to be selected without passing through intermediate ranges.



New Portable Stroboscope

MODEL 1210, the newly developed stroboscope of Communication Measurements Laboratory, 120 Greenwich St., New York 6, employs a new circuit arrangement using a self-blocking oscillator. Rotary or vibratory motion that may be stopped ranges from 600 to 48,000 cycles per minute, covered in four steps. For accurate calibration against the line frequency, a synchronized reed is provided. All scales can be calibrated easily and quickly within plus or minus three per cent. The light source is contained in a probe attached to a four-foot flexible cable. This feature makes the model especially useful when using stroboscopic light in a small out-of-the-way place.

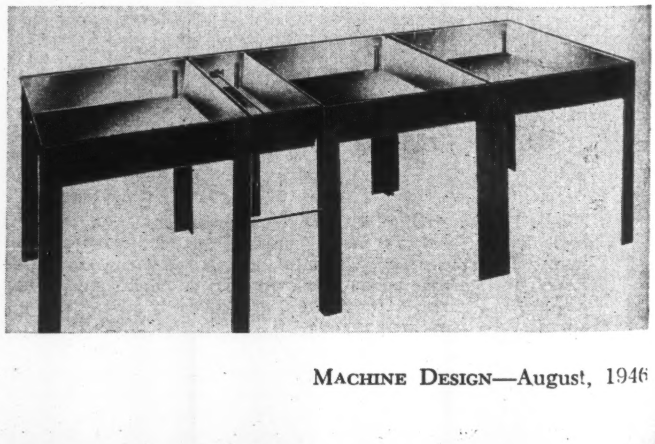


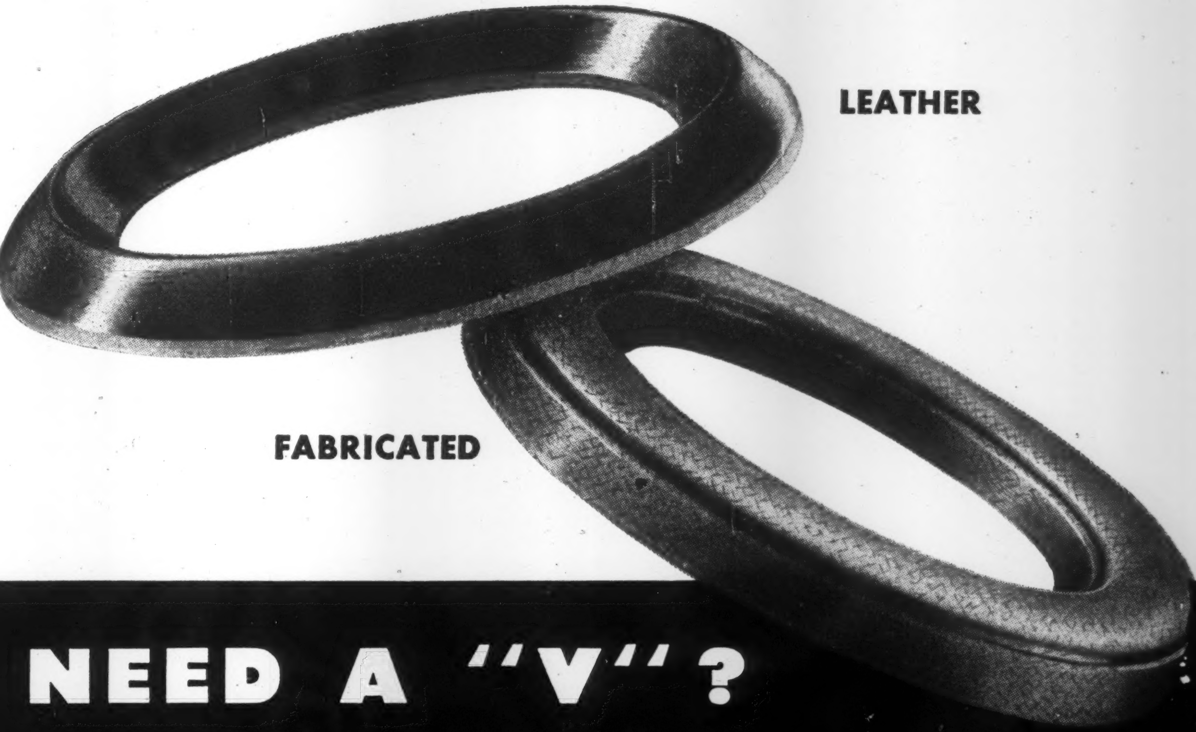
Printing and Developing Machine

WHITEPRINTS in cut sheets or rolls, in one continuous operation at 30 feet per minute, are made by the Pease 88-R printing and developing machine. Easy to operate, the machine, made by the C. F. Pease Co., 2601 West Driving Park Road, Chicago 18, is said to require minimum operator attention and to provide maximum operator comfort. Virtually everything but feeding the tracings and papers is automatic. An outstanding feature of the printer is the optional use of revolving or sliding contact. This is achieved by a simple clutch lever, allowing the operator to instantly convert from revolve to sliding-revolve in which the cylinder runs slightly faster than the tapes. The contact cylinder is cooled by the same blower which forms the vacuum to convey exposed prints to the ammonia-fume developer. The machine has arc welded heavy structural steel framework and 18 gage sheet metal exterior. Parts exposed to ammonia fumes are fabricated of stainless steel or aluminum.

Developing Tanks

DESIGNED for long life in developing, fixing and washing processes for photo, photocopy prints, and blueprints, is a set of stainless steel developing tanks announced by Peck and Harvey, 5736 N. Western Avenue, Chicago 45. Consisting of three tanks 32 inches wide and 44 inches long, and one tank, 12 inches wide and 44 inches long, the units are continuous-welded stainless steel with outside edges rolled. Features of the unit include demountable legs, lightweight plastic agitator, and removable interlocking-rod joining the individual tanks to form a unit.





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VIM **Leather and** ***VIX-SYN*** **Packings**

HOMOGENEOUS

...and "O" rings, too!

Get these popular packing rings from Houghton without danger of patent infringement. We supply back-up washers of leather, too, for use at higher pressures. A complete line, all from one source—E. F. Houghton & Co., Philadelphia and principal cities.

ASSETS to a BOOKCASE

Rolling Bearings

By R. K. Allan; published by Pitman Publishing Corp., New York; 401 pages, 5½ by 8 ¾ inches available through Machine Design, $8.50 *postpaid.*

Here is an excellent treatment of the subject of ball and roller bearings which should be of outstanding interest and value to designers of all types of machines. The author provides a thorough study of antifriction bearings covering fundamental analyses and basic facts clearly set forth in easily understood terms.

Certain materials and methods of manufacture are treated which will assist greatly in making reasonable selection and application of antifriction bearings. Basic theories and practical formulas developed in following chapters are made eminently useful and understandable by a generous selection of typical problems and their solutions.

Chapters on selection and application factors in general round out the text with comprehensive discussions on bearing characteristics, preloading, machine characteristics, loads and speeds, vibration, temperature, shaft and housing design, fillets, shoulders, seals for all purposes, cooling, etc. Material covered in the chapter on lubrication should prove of great help to anyone concerned with special antifriction bearing problems as should further chapters on service performance, maintenance, and fits and limits. An unusually complete reference bibliography at the conclusion gives pertinent literature dating from 1881 to 1943.

□ □ □

Theory of Structures

By Stephen Timoshenko, Professor of Theoretical and Applied Mechanics, Stanford University; and D. H. Young, Associate Professor of Civil Engineering, Stanford University; Published by McGraw-Hill Book Co., Inc., New York; 488 pages, 6 x 9 inches, clothbound; available through Machine Design, $5.00 *postpaid.*

Keeping in mind the fact that the theory of structures is based upon an extension of mechanics, the authors have prepared a volume in which a close connection is made with the principles of mechanics familiar to the reader. With this point of view, understanding of the practical methods of analysis of frames and trusses is facilitated. Investigations are made in the analysis of space and plane structures with the thoroughness characteristic of the authors.

Introducing the reader to the subject by a recapitulation of some principles of statics, the funicular polygon, elements of plane statics, bending-moment diagrams, and other pertinent aspects are discussed. The examples are so chosen as to illustrate the adaptation of these principles to the solution of practical problems in the anlaysis of simple structures. Having established the relationship between the branches of analysis, the authors develop their discussion along the conventional lines of approach. Analysis of plane trusses, influence lines, space trusses with hinged joints, truss deflections, bending of beams, and the theory of arches are treated. Preparatory to the consideration of statically indeterminate structures, the authors have introduced a chapter giving attention to the general principles of mechanics. The expressions for strain energy are developed. Basic principles such as Castigleano's theorem, and Maxwell's theorem, as well as the principles of least work, and superposition are considered carefully and in some detail.

Treatment of the subject is thorough and careful throughout. As an aid to the reader, two typefaces have been used. Basic information has been presented in the larger size. More advanced material has been printed in smaller type, facilitating preliminary study of the work.

□ □ □

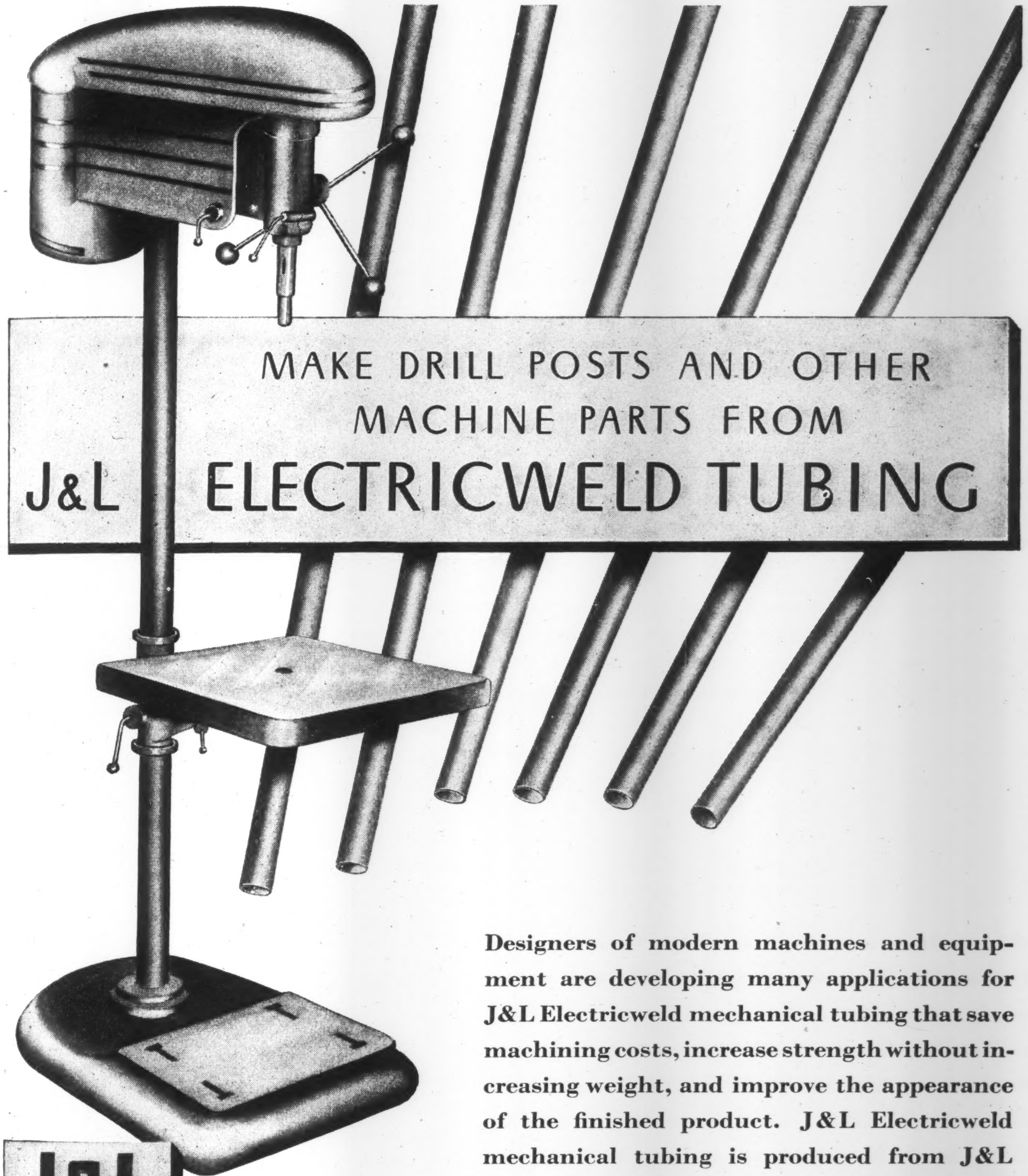
Electrical Drafting

By D. Walter Van Gieson, assistant electrical engineer, Board of Transportation, City of New York; published by McGraw-Hill Book Co. Inc., New York; 136 pages, 5¼ by 8⅛ inches, clothbound; available through Machine Design, $1.50 *postpaid.*

Greatly increased use of electrically operated and electric, electronic, or radar controlled machines has lent considerable impetus to the demand for designers having thorough working knowledge of electrical drafting procedures and standards. Written to serve both as a textbook for students and a reference manual for engineers associated with the electrical field, this book seems to meet a long-felt need.

To the machine designer planning the incorporation of electrical controls, a knowledge of wiring plans as well as methods of their execution and development are of primary importance. By means of a graded series of drawing plates and explanations, the author works from a simple form of electrical diagram to those which are more complex, and at the same time develops the detailed wiring plan along with the accompanying equipment-location plans.

Covered in the text are: Circuits and wiring plans for lighting, railway signals, communications, radio and television, power, cars, ships, aircraft, etc. No attempt is made to dwell on any phase of machine drafting other than that directly concerning electrical wiring plans. Practical in scope, the book is well written and should prove of value in promoting a unified, understandable electrical drafting standard.



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Design Abstracts

Appearance Should Identify Make

WHETHER a business is of small, easily controlled size or is a large, highly departmentalized operation, there have been more businesses built or broken through design than for almost any other reason. Yet many manufacturers will spend time and money in every single phase of their business except in the matter of how the finished product will look. Design becomes the early recognizable "handwriting" or "trade-mark" of any business. The manufacturer must establish a design policy and adhere to it, develop it and promote it. It is important that designers know their medium of production thoroughly, bear in mind the end use of the product, keep up with current related trends and, above all, be original.—*From a talk by Burton Ames, Decorative Fabrics division, Celanese Corp. of America, presented at a meeting of the New York chapter of the American Designers' Institute.*

Recovering Waste Heat from Diesels

MOST likely methods by which the diesel engine of the future will be improved are: Increasing the rotative speed, increasing the brake mean effective pressure, and increasing the overall thermal efficiency of the engine.

In addition to obtaining more horsepower from engines, operation of the present-day diesel can be improved by means of heat recovery. Two possible sources for recovering BTU's now ordinarily lost are the engine jacket cooling water and the engine exhaust gases. By means of a heat exchanger all the heat contained in the engine jacket water, representing approximately 31 per cent of the BTU's in the fuel consumed, can be recovered. By installing a water-cooled exhaust manifold, this recovery can be increased by approximately 9 per cent, making the total heat recovered from the jacket water equal to around 40 per cent. By the use of an exhaust gas heat economizer, the average efficiency of which is 55 per cent, an additional 9 per cent of the total BTU's consumed can be recovered from the exhaust gases.

The total of these various economies amount to 49 per cent. Add this figure to the thermal efficiency of the conventional type Diesel and the overall thermal efficiency becomes 81 per cent. In other words, for every 100 BTU's of fuel consumed 81 can be made available for producing useful work in installations requiring heat for process work or plant heating. There appear possibilities for improving even this figure by a new type of jacket water cooling system known as vapor-phase high-temperature cooling.

This system consists of using a closed pressure circuit for the jacket cooling water. By raising the pressure, the boiling point temperature of the jacket water is also raised. For example with a pressure of 5 psi gage on the system the boiling point of the jacket water would be about 227 F. Should process work of a plant require steam at 5 psi gage, jacket water under 6 psi gage pressure could be released at 5 psi at which pressure a proportion of it would flash into steam. It is claimed that the overall thermal efficiency of one diesel plant has been increased from the normal 32 per cent to a total of 82 per cent by this method. By such means the diesel engine of the future can retain its leadership among all present types of prime movers with reference to its overall thermal efficiency.—*From a paper by W. C. Burgy, supervisor of engine sales training, Caterpillar Tractor Co., presented at a recent meeting of the Louisville, Ky., Chapter of the National Association of Power Engineers.*

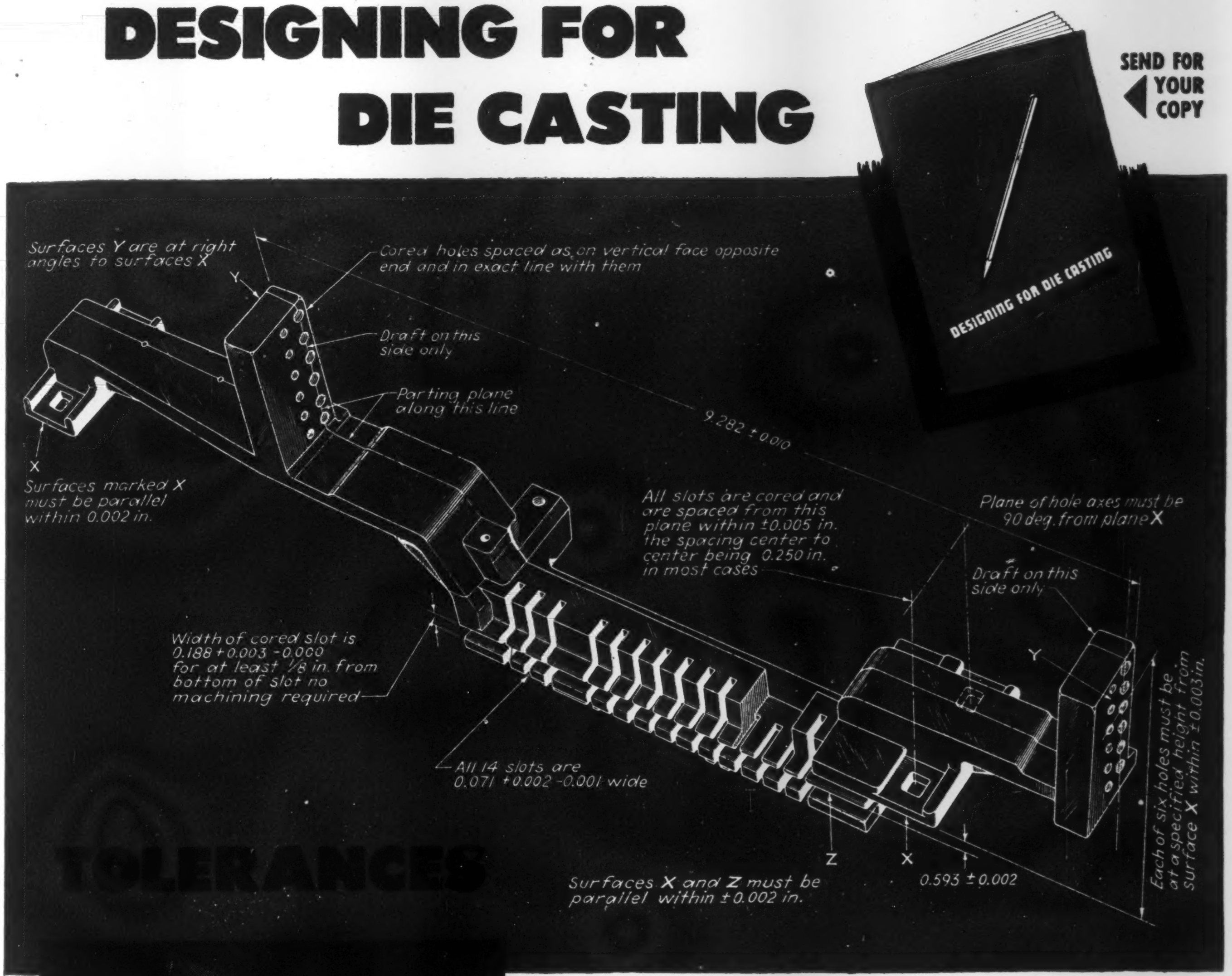
Industrial Design and the Public

GOOD design should be the crystallizing of the public's desire at the exact moment it becomes aware of that desire. Thus, it can be said that good design is compromise between what the designer wants to do and what the public is ready for. There is no place in the design field for the Ivory Tower genius who has lost touch with the public; design alone does not run factories or tinkle cash registers. Successful design not only makes the original desire or need more compelling and attractive, but it must result in sales. Design without sales is merely a drawing board exercise or an artist's excursion into the stratosphere.

Some industrial designers—the Airbrush boys—have made spectacles of themselves and have done the profession little good in the last few years. I am here neither to apologize for nor to defend them. I don't think they have done too much damage and certainly they have had a good time for themselves. A great many of them, I believe, have been intrinsically honest but unable to read the clues to public acceptance. Others, not so honest, have drunk a little too much heady publicity before sitting down to work. But whatever their motives—the public inevitably will dispose of them by refusing to buy. And without sales the air brushes will soon be gathering dust.

The public can be led by intelligent design but always along a continuation of the beaten path—its habit pattern and previous conditioning. Driving the public into unknown territory without a guide-line extending back to the past, if not an impossibility, has never been done. I would like to illustrate the force of habit pattern upon design acceptance even among engineers—who should qualify as pioneers if any group should. My firm recently completed a helicopter design for a famed Eastern aircraft builder. One design was a perfect egg-shaped air-foil, with pilot and passengers seated directly behind a Plexiglas arc. Visibility and streamlining were perfect—but the engineers hesitated and I knew what was wrong. All, of course, were automobile drivers, inbred to the habit pattern of having a hood in front of them in any moving vehicle. They had not been conditioned to the almost negligible protection such a projection affords. So, because at helicopter speeds

DESIGNING FOR DIE CASTING


DESIGNING FOR DIE CASTING
Surfaces Y are at right angles to surfaces X
Y
Cored holes spaced as on vertical face opposite end and in exact line with them
Draft on this side only
Parting plane along this line
9.282 ± 0.010
X
Surfaces marked X must be parallel within 0.002 in.
All slots are cored and are spaced from this plane within ±0.005 in. the spacing center to center being 0.250 in. in most cases
Plane of hole axes must be 90 deg. from plane X
Draft on this side only
Y
Width of cored slot is 0.188 + 0.003 − 0.000 for at least 1/8 in. from bottom of slot no machining required
All 14 slots are 0.071 + 0.002 − 0.001 wide
Each of six holes must be at a specified height from surface X within ±0.003 in.
TOLERANCES
Z
X
0.593 ± 0.002
Surfaces X and Z must be parallel within ±0.002 in.

SEND FOR YOUR COPY

In designing die castings, *never specify tolerances closer than are essential to meet requirements* since it may cost much more to hold close dimensions than to allow them to come within somewhat wider limits.

Where close tolerances *are* essential, however, the die casting process is capable of doing a quite remarkable job. An outstanding example is the above *zinc alloy* die casting used in communications equipment. The tolerances shown on the drawing are all *as-cast*—and all critical holes are cored to tapping size! Each casting is checked in the special fixture illustrated to make certain that all dimensions are within the limits specified.

For *zinc alloy* die castings, the *minimum* tolerance—*as-cast*—is usually ± .001″ *per inch* where the dimension is within solid parts of the die not having relative motion. Where the dimension is across a parting, or between parts of the casting formed by movable cores or slides, wider limits should be specified or provision for machining must be made.

Additional data on tolerances and other design considerations will be found in our booklet "Designing For Die Casting." To insure that you will get the most from your die casting dollar, ask us—or your die casting source—for a free copy of this booklet.

ZINC
FOR DIE CASTING ALLOYS

THE NEW JERSEY ZINC COMPANY, 160 FRONT ST., NEW YORK 7, N. Y.

The Research was done, the Alloys were developed, and most Die Castings are based on
HORSE HEAD SPECIAL (99.99+% Uniform Quality) ZINC

a perfect airfoil is not too important, we came up with a variation of the first design. This time we used what we call a "broken nose"—an incision of the egg-shape which gives the leading surface something resembling an automobile hood. That design was accepted readily and is in production today. In the first design old habit forms created a subconscious feeling of insecurity. In the second design insecurity was replaced by a sense of security—comforting, however unsubstantiated by facts.

However intelligent, however educated the man, human psychology remains essentially the psychology of the primitive man. He is comfortable and secure in the presence of the familiar—he recoils in the face of the unknown. He wants neither to lead the parade nor to follow it. His exact security center is the middle, although adroit design may lead him farther to the front than he is sometimes aware.—*From a paper by R. E. Bingman, designer, presented at the SAE summer meeting in French Lick, Ind.*

Applying High-Speed Chains

REQUIREMENTS for a positive high-speed drive on automatic screw machines were foreseen with the ever-widening variety of new materials being produced, the constant demand for increased production, and the desirability for greater machine efficiency. It was believed that a high-speed chain drive, properly applied, would offer a means which would permit greater utilization of the machine capacity, provide the necessary additional power desired, and produce a drive which would operate with greater reliability and economy than had been heretofore possible.

Highly promising tests have been made and are at the present time underway with ⅜-inch pitch triple chains. The loads on a chain in order of importance may be considered as: (1) Impact load, (2) Centrifugal force, and (3) Idler tension. Comparing ½-inch and ⅜-inch pitch chains, it will be appreciated that the smaller pitch chain, being of lesser weight, has the lower impact velocity. Centrifugal force is a function of chain weight and speed; by using a ⅜-inch pitch, the centrifugal force is reduced 22 per cent from its value in a ½-inch pitch chain.

High-speed chain-drive application is satisfactory when certain conditions are fulfilled. It has been our experience that these spindle-driving chains should first be "run in" before being applied to machines. Regular commercial chains wear rapidly during the first hours of operation, necessitating frequent adjustment of the idler sprocket and eventual removal of chain links. A chain which elongates and operates with improper tension will ride out on its sprockets, permitting the rollers to strike the tips of the sprocket teeth and leading to early destruction of both chain and sprockets. Consequently, for maximum chain life, we recommend "run-in" chains, sprockets accurately cut both as to index and tooth form, together with good lubrication and proper tension adjustment at all times.

In summing up the advance made by the application of chain drive, it has been found that the chains are ample to carry the work loads and withstand satisfactorily the shock of repeated reversals; with proper lubrication, wear is reduced to a point where long life can be secured.

Although operating conditions are admittedly severe (majority of tests made at maximum speed and reverse cycle), highly desirable reductions in maintenance and replacement costs have resulted, as well as freedom from breakdown. These are decided assets in that they prevent interruption of the regular high production schedules to which the machines are applied.—*From a paper by A. W. Meyer, Brown & Sharpe Mfg. Co., presented at the Machine Design group session of the recent ASME semiannual meeting in Detroit.*

Where Cooperative Research Fits

A CRITICISM sometimes leveled against cooperative research is lack of achievement in the outposts of science and design. Such criticism reveals a misunderstanding of the true sphere of cooperative research. The outposts of scientific research are best occupied by experimenters of singular brilliance and organizations with specialized equipment. New designs originate from men of creative genius, the inventors, and are developed by commercial organizations.

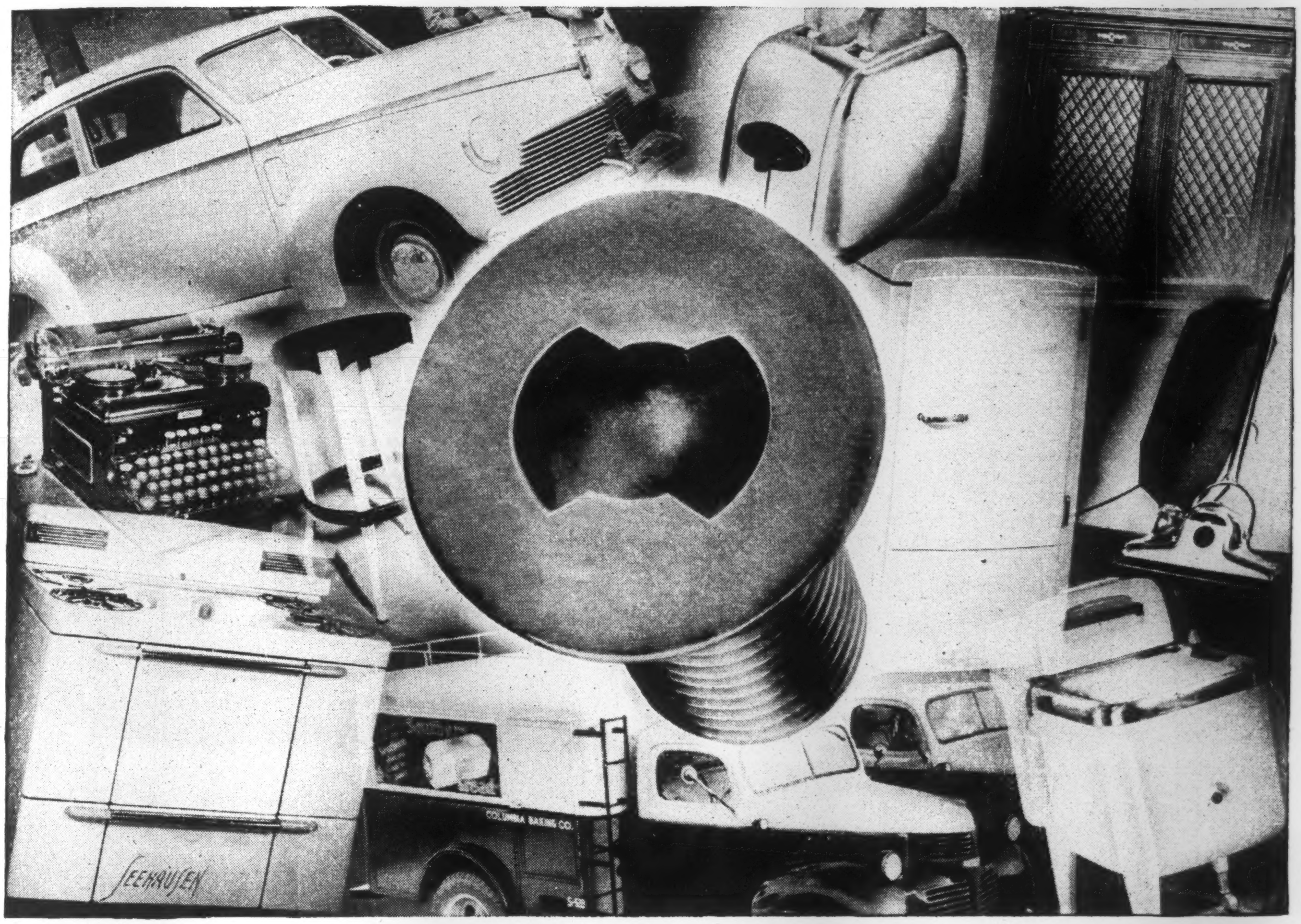
Cooperative research, involving the united efforts of many persons, must not aspire to the role of the pioneer. Since it represents many different industrial organizations, it must not infringe upon the design and development prerogatives of the individual industrial concern. In the broad general or collective application of the principle and the utilization of the design lies the function of cooperative research. It must bring such knowledge into the forefront of technical consciousness and, spreading it among greater numbers, give it the familiarity which leads to understanding, assimilation, appreciation, and general utilization.

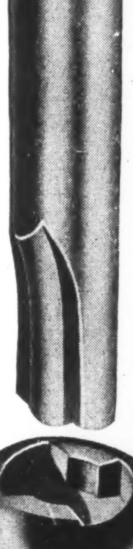
As handmaiden to the gods of science and design, cooperative research, while humble, significantly accelerates the onward march of technical progress. This advance has always been halted by that weary wait between the discovery of a new bit of knowledge and its general application. A contemporary scientist when asked the difference between pure science and industrial research replied: "Twenty years."

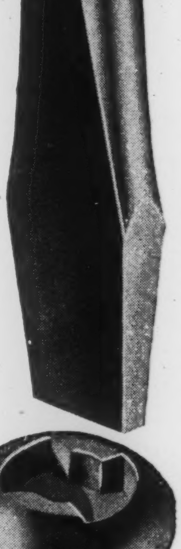
Cooperative research, defined as purposeful organized investigation in the field of the general application of principles embracing the efforts of all interested and qualified sections of industry, will help bridge the gap between the known and the used.

A frequently asked question is, what criterion should be applied to determine whether or not a project should be undertaken. The answer to this is simple, certain and practical, although sometimes shocking to the idealist questioner. A project should be undertaken only when industry is willing to pay for it.

That needed knowledge is lacking on a particular topic is no justification, in itself, for carrying out cooperative research. The knowldege required may be of limited applicability, or it may be ahead of industry's thinking; in either case it will not be used or useful even if developed. If industry is willing to pay for a cooperative project, that project is born with three inherent elements of successful research: The knowledge which it is planned to provide is needed, that need is widely felt, and the results obtained will be immediately accepted and used.—*From a talk by C. B. Veal, Coordinating Research Council Inc., presented at the recent annual meeting of the SAE.*







Whatever Your Product . . .

Clutch Heads Will Streamline Your Assembly Line

Because this modern screw offers you features not matched by any other screw on the market . . . for lower-cost, safer, faster, easier driving.

Here is the evidence . . . direct from the records of CLUTCH HEAD users:

"ASSEMBLY COSTS CUT 22%"
"ZERO IN DAMAGE FROM DRIVER SLIPPAGE"
"THE TYPE 'A' BIT OUTLASTS OTHER BITS 5 TO 1"
"SCREWDRIVER OPERATION SIMPLIFIES FIELD SERVICE"

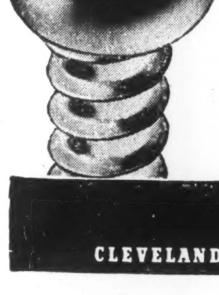
The CLUTCH HEAD recess inspires operator confidence with an easy-to-hit target.

All-square contact eliminates need for end pressure to combat "ride-out" as set up by tapered driving.

The Center Pivot column insures dead-center entry for "no-canting" drive home.

The CLUTCH HEAD Lock-On unites screw and bit as a unit for easy one-handed reaching to hard-to-get-at spots.

Compare these features. Send for samples of screws and of the Type "A" Bit



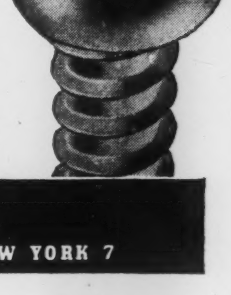
Drives Extra Thousands of Screws

What other bit offers the stamina for long uninterrupted driving, plus the economy of 60-second on-the-spot reconditioning? A simple application of the end surface to a grinding wheel restores this bit to original efficiency.

CLUTCH HEAD SCREWS

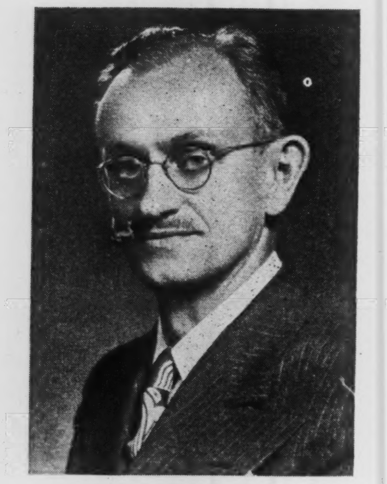
No Field Service Problem Here

What other screw disposes of servicing "headaches"? CLUTCH HEAD is basically designed for operation with any common screwdriver which need only be reasonably accurate in width. Thickness of the blade is secondary.

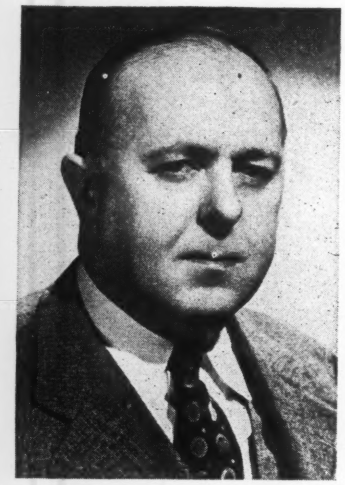


UNITED SCREW AND BOLT CORPORATION

CLEVELAND 2 CHICAGO 8 NEW YORK 7



Howard F. MacMillin



Frank J. Wood

John O. Almen

MEN... of machines

HOWARD F. MacMILLIN, well known as one of the leaders in the engineering development and manufacture of hydraulic presses and other production machinery, has been elected vice president of Bryant Machinery & Engineering Co. After receiving his mechanical engineering degree from Massachusetts Institute of Technology in 1921, he became connected with Hydraulic Press Mfg. Co. and served in various engineering and executive capacities until 1938. Since then until 1944 he directed the company as its president and general manager. In 1945 he became affiliated with Arthur D. Little Inc., a research organization, with which he is continuing his connection in addition to his new position. As vice president of the Bryant organization he assumes general executive responsibilities and directs the company's business in the fields of mechanical and hydraulic presses and special production and industrial machinery.

FRANK J. WOOD, formerly with Goodman Mfg. Co., has become chief engineer of the Rolling Mill Division, Loewy Construction Co. Inc. Mr. Wood began his steel mill career with National Tube Co., Pennsylvania Works, in 1917 after attending Carnegie Institute of Technology. During World War I he served with the Railway Artillery Engineer Corps and, upon returning, was made assistant chief engineer of National Tube. In 1924 he became resident engineer of the Pittsburgh district for Crucible Steel Co. He resigned in 1927 to become department engineer for Mesta Machine Co., and five years later joined the Leningrad staff of Freyn Engineering as rolling mill consultant. Upon his return to the United States he spent two years as special engineer, Brass Mill Division, Western Cartridge Co. In 1936 he became chief engineer of the industrial division of Goodman Mfg. Co. and, for the past ten years, has specialized in the design of special equipment for the ferrous and nonferrous industries.

JOHN O. ALMEN, an automotive engineer, has received the Edward P. Connell award for 1945, presented by the American Gear Manufacturers Association. Mr. Almen, who received his engineering training at Washington State College, began his career with a number of years in various engineering positions on the Pacific coast, the principal one being the development of barrel-type engines in co-operation with the Army

THESE PRECISION-BUILT *Packing Rings* CUT PRODUCTION TIME

Are you looking for a packing ring of mechanically perfect fit to save time on assembly operations and cut production costs?

There is a Johns-Manville Die Formed Ring that's exactly suited for the job!

Custom-made to closely controlled dimensions, these precision rings have proved the answer to many a designer's problem. They are available in virtually any size and flange width required and are furnished in many styles and compositions, with or without wire insertion and lubricated for the specific service condition.

Consult the check list below to find out which style of J-M Die Formed Ring is best suited to your needs. For additional information, write Johns-Manville, Box 290, New York 16, N. Y.

CHECK LIST FOR THE PRODUCT DESIGNER

Name	Style No.	Description	Recommended for	Maximum Depths and Minimum Sizes		
				Flange Width	Max. Depth	Minimum Size
Jewett	R-10	Braided wire-inserted asbestos jackets over a thin lead core	General service up to 500° F	1/16" Over 1/16" thru 3/32" Over 3/32" thru 7/64" Over 7/64" thru 1/8" Over 1/8"	5/16" 3/8" 7/16" 1/2" 5/8"	3/16"x5/16"x3/16"
	R-9	Same composition as R-10, except softer	Especially for bibs and faucets			
	R-14	Wire-inserted pure asbestos jackets, braided	General service over 500° F			
Mogul	R-223	Braided asbestos jackets, very pliable	General service up to 500° F			
Gasoline	R-323	Braided asbestos jackets, specially lubricated	Hot or cold solvents			
Rajah	R-6	Frictioned braided asbestos jackets	Temperatures over 500° F			
Centripac	R-7	Plaited asbestos yarns	General service up to 500° F	3/16" thru 1/2" Over 1/2"	Flange + 1/8" Flange + 1/4"	3/4"x1 1/8"x3/16"
	R-11	Plaited wire-inserted asbestos yarns	General heavy duty service up to 500° F			
	R-18	Plaited asbestos yarns, specially lubricated	Hot or cold solvents			
Flexible Metallic	R-350	Plaited asbestos yarns and lead ribbons	High or low pressure steam, air, water and oils up to 500° F	3/16" thru 1/2" Over 1/2"	Flange + 1/8" Flange + 1/4"	3/8"x3/4"x3/16"
	R-351	Plaited asbestos yarns and lead ribbons, specially lubricated	Hot or cold solvents			
Endless	R-341	Frictioned braided asbestos jackets	General service up to 500°F	1/16" and over	1/2"	1/4"x3/8"x3/16"
Plastic	Various	Various compositions, depending on service	Various fluids and gases	1/16" Over 1/16"	3/8" 9/16"	1/8"x1/4"x1/4" Maximum O.D. endless, 1 1/2"

Johns-Manville ***PACKINGS & GASKETS***

Air Corps at McCook Field. Since 1926 Mr. Almen has been connected with General Motors Research Laboratories as head of the Mechanical Engineering Department 1. During this period he has been active in automobile engineering problems ranging from bodies to suspension systems, and from engines to rear axles with particular emphasis on transmission and rear axle gears. A similar range of subjects is covered by patents, approximately seventy-five in number, that have been issued to Mr. Almen. He was a pioneer in the development of extreme-pressure lubricants and designed several machines that are being used for testing gear lubricants and engine bearings. In addition he fostered the development of resonance intake and exhaust silencers, automatic valve adjusters, automatic transmissions and controls, and plate spring clutches. During the late war Mr. Almen devoted most of his time to strength of materials problems under the auspices of the National Defense Research Council.

◆

Carlos E. Harrington, the new chief engineer of Winfield H. Smith Inc., is in full charge of design, research and development work. Mr. Harrington during the war acted as chief engineer for the Amphibian Car Corp. and is one of the patentees of an amphibious vehicle. Prior to joining Winfield H. Smith Inc., he designed and tooled large Farnham spar cap mills for the aircraft industry.

◆

Burton E. Shaw has been elected a vice president of Photoswitch Inc., and will have charge of engineering and production. Mr. Shaw formerly had been vice president in charge of engineering for Watts Regulator Co.

◆

I. C. Smith, connected with The Crocker-Wheeler Division of Joshua Hendy Iron Works since 1942 as a designer of direct-current motor and generator equipment, has been appointed chief engineer of the division.

◆

C. M. Sloat, former project engineer of Curtis-Wright, has joined Lion Fastener Inc., as chief engineer.

◆

Justin J. Wetzler and J. Harvey Chandler have been appointed director of engineering and chief engineer, respectively, of Barnes & Reinecke, designers and engineers.

◆

Dr. Royal K. Abbott, a member of the Pittsfield Laboratory of General Electric Co. for the past three years, has left for Rio de Janeiro, Brazil, where he will be laboratory director for General Electric, S. A.

◆

Alexander W. Luce has been appointed head of the department of mechanical engineering at Pratt Institute. Effective September 1, Professor Luce will resign from the Fellows Gear Shaper Co., where since 1942 he has been mechanical engineer on production and personnel problems. He will, however, continue to serve as consulting engineer.

◆

Prof. John L. Carruthers has been named chairman of the department of ceramic engineering at Ohio State University, succeeding Prof. Arthur S. Watts, who is retiring after twenty-two years' service to the university, twenty as chairman of the department. Professor Carruthers belongs to numerous scientific and technical groups and has served as president of the Institute of Ceramic Engineers and of the American Ceramic Society.

◆

Machine Design offers apologies to H. D. Kelsey, recently appointed managing engineer of General Electric company's new aircraft gas turbine division, and to J. Elmer Housley, the new presidential nominee of the American Institute of Electrical Engineers, for the transposition in its June issue of the photographs in connection with announcements of the foregoing appointments.

Mr. Kelsey, at left, joined General Electric in 1920 immediately upon graduation in 1920. He served in various engineering capacities until his appointment in 1944 as works manager supervising all engineering work. Now as managing engineer of the new aircraft gas turbine division, Mr. Kelsey is in charge of both engineering and manufacturing turbines.

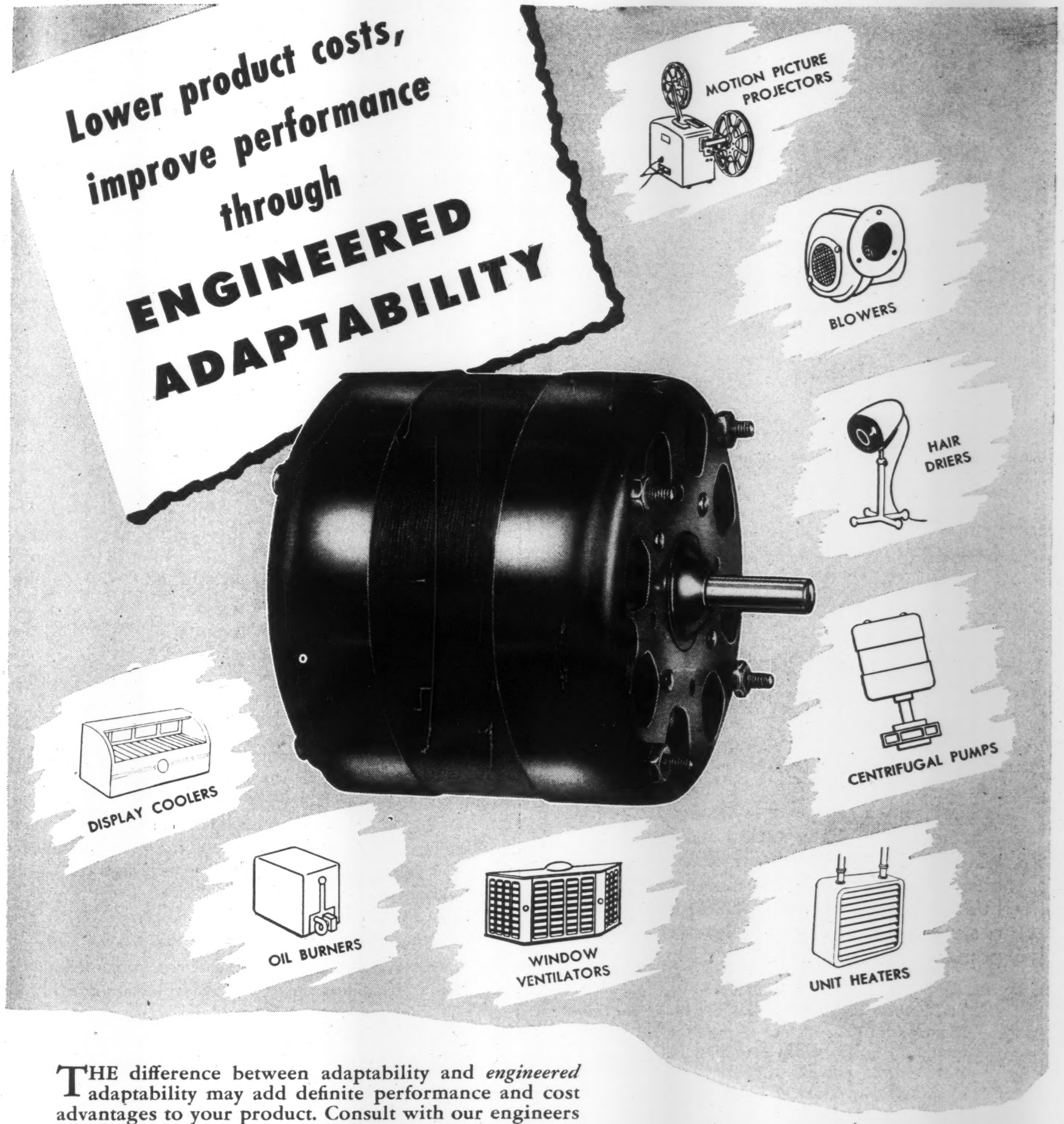
Mr. Housley, at right, nominated for president of the American Institute of Electrical Engineers, is district power manager of Aluminum Co. of America. He has been associated with the company in many capacities since 1915. In 1927 he was made head of the engineering, operation and maintenance of the hydro-electric power system of the company in Eastern Tennessee and Western North Carolina. He has been actively identified with the problems of interconnected power system operation, load and frequency control, telemetering and carrier current relaying and communications.

◆

Robert A. Cole has joined Boeing Aircraft Co., Seattle, Wash., as associate engineer of research.

◆

Hilbert E. Edwards has been appointed section engineer in charge of laundry equipment engineering of Westinghouse Electric Corp. Mr. Edwards had been in charge


Lower product costs,
improve performance
through
ENGINEERED
ADAPTABILITY
MOTION PICTURE PROJECTORS
BLOWERS
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CENTRIFUGAL PUMPS
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WINDOW VENTILATORS
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THE difference between adaptability and *engineered* adaptability may add definite performance and cost advantages to your product. Consult with our engineers NOW if you plan to use production-run quantities of small motors (1/500 to 1/15 H.P.) in your 1947 products. A skilled experienced factory engineer will meet with your engineers in your own plant. He'll make a thorough study of your product design and probably recommend a motor of standard type. *But,* he'll *engineer* the physical and electrical characteristics of the motor—varying them to adapt the motor *specifically* to your product. Write today, describing briefly your product design plans.

F. A. SMITH MANUFACTURING CO., INC.
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FASCO

Pilot
Fractional H.P.
MOTORS & BLOWERS

ACRO'S *Sturdier* MODEL "M"

1. BASIC MODEL "M"

2. MODEL "M" WITH A-18 LEAF BRACKET.

3. MODEL "M" WITH A-18-M ROLLER LEAF BRACKET.

In keeping with the ever-widening demand for small ACRO Snap Action Switches, built with the patented Beryllium Rolling Spring and with the experience gained in building hundreds of thousands, ACRO now adds a sturdier, more durable housing for its popular long life Model "M".

NEW FEATURES

1. ***New stronger molded case*** — cover recessed into case, clear of the four 3/32" mounting holes. • **2.** ***Sturdier barriers between terminals,*** affording generous electrical clearances. • **3.** ***Heavier solder terminals*** with .082" terminal holes for easier wiring. • **4.** ***Greater compactness*** for multiple assemblies — four can be mounted in a space of *less than* 1⅛".

This better built, better performing switch is made with single pole, single or double throw contacts — rated at 10 amps. 125 volts A. C. Can be fitted with leaf actuators illustrated above. For immediate help on your switch problems, send full details of operating characteristics required and proposed assembly.

ACRO ELECTRIC COMPANY

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of development and engineering of the company's automatic washing machine and, in his new position, will supervise the future development of the washing machine as well as plans for the company's ironer and dryer.

◆

G. S. GARRARD, formerly chief engineer of Briggs Filtration Co., Bethesda, Md., has been appointed chief engineer of Jacobs Aircraft Engine Co., Pottstown, Pa.

◆

CHARLES MARIEN SR. in his new post as director of engineering for Ramsey Corp., St. Louis, will carry forward the company's research program which he has headed as chief engineer for the past sixteen years. W. M. MARIEN, who for the past several years has been working on developments in piston-ring engineering, replaces his father as chief engineer.

◆

B. FRANK JONES recently resigned as engineer in charge of White Motor company's engineering problems during the war to become chief engineer of the Autocar Co., Ardmore, Pa.

◆

BEN F. JONES has been made director of aeronautical research with the B. F. Goodrich Co. Prior to his appointment Mr. Jones served as manager of the de-icer development and research department.

◆

ORVILLE L. WILKINSON has joined the Hydro-Aire Co. as design engineer. He had formerly been design group engineer, Airesearch Mfg. Co., Los Angeles.

◆

T. H. MURPHY, superintendent of diesel power, American Locomotive Co., Schenectady, N. Y., has been made administrative assistant to the director of engineering. H. B. DHONAU, assistant chief design engineer of the two-cycle diesel division of the company, recently was made assistant department head of the same division.

◆

DR. R. M. REICHL, who represented Hydropress Inc., as consulting engineer in many new developments for the Army, Navy and Air Forces, has been promoted to the position of vice president. Dr. Reichl has wide experience in the design, construction and operation of hydraulic presses and rolling mills for the ferrous and nonferrous industries.

◆

WINTHROP A. JOHNS, former chief engineer of Atlantic Diesel Corp., New Brunswick, N. J., is now a vice president of Vibradamp Inc., same city.

◆

ROBERT H. PETERSON has joined Radio Corp. of America, Lancaster, Pa., as development engineer. He had been associated with the Stromberg Aircraft Carburetor Division of Bendix Products Division, South Bend, Ind., in the same capacity.

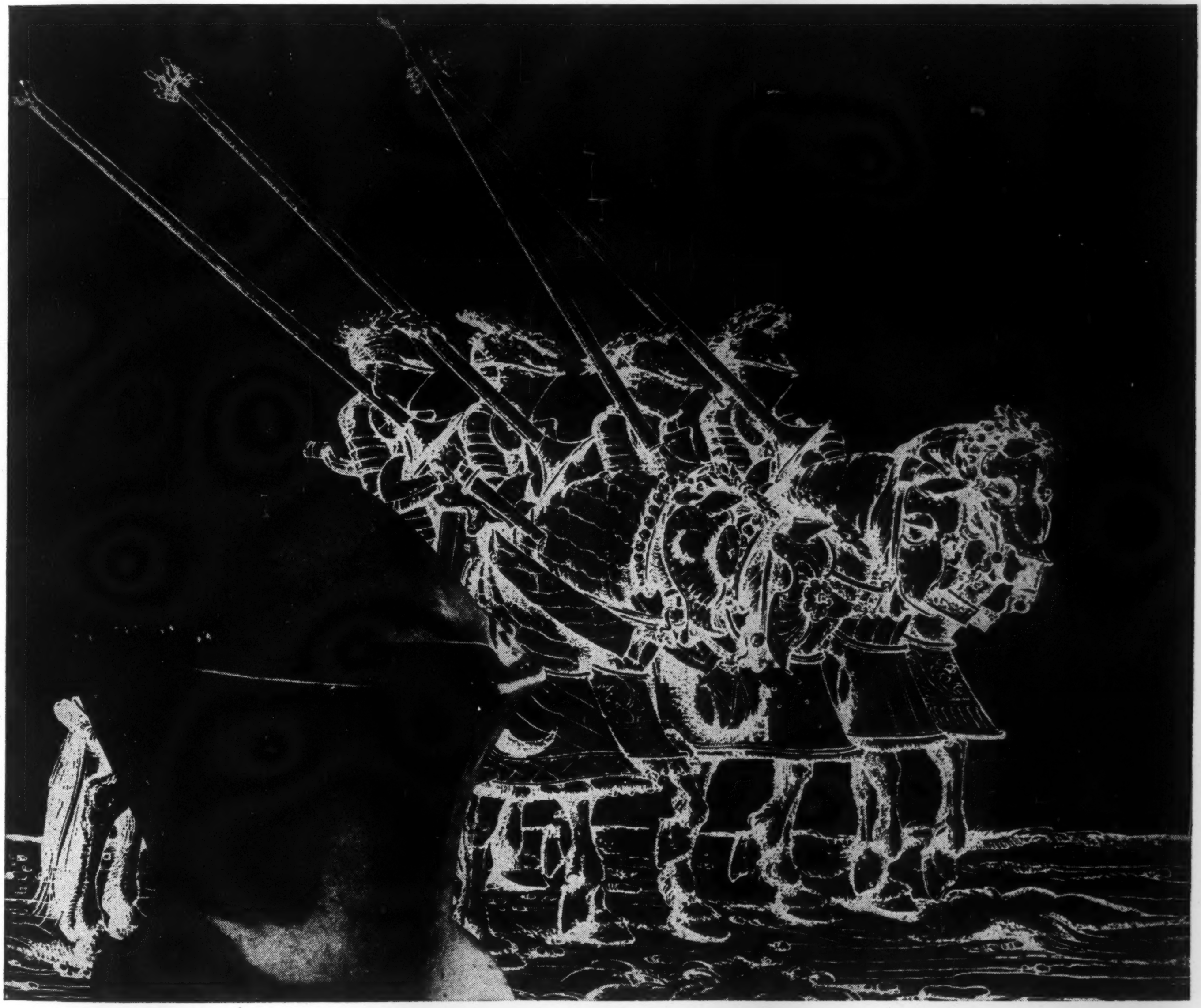
◆

CORRECTION: It was erroneously reported that James C. Barnaby had been appointed assistant director of research and development of Worthington Pump & Machinery Corp. Mr. Barnaby is now and has been for some years consulting engineer on the general staff of the company.

MATERIALS MAKE PERFORMANCE

Several centuries ago the Chevalier de Roye swept the tournaments until a broken saddle girth made him non-operational. A promising career was ruined by a material weakness missed by routine inspection.

Temper brittleness in steel is a modern material weakness that is easily overlooked, and likely to be fatal to product performance and sales. The adoption of temper-brittle-free molybdenum steels will eliminate this risk . . . and they will do the job well and economically.



MOLYBDIC OXIDE—BRIQUETTED OR CANNED • FERROMOLYBDENUM • "CALCIUM MOLYBDATE"
CLIMAX FURNISHES AUTHORITATIVE ENGINEERING DATA ON MOLYBDENUM APPLICATIONS.

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MOLY

This NEW hardened screw TAPS its own threads!

ACTUALLY TAPS THREADS IN ALL KINDS of METAL, CASTINGS, ALLOY, RUBBER, PLASTIC

HOLTITE 'TAP' SCREW

U.S. Pat. No. 2,292,195

Other patents pending

Furnished with Slotted or HOLTITE-Phillips Recessed Heads...All Styles

Pilot point inserted in hole aligns screw for straight driving.....

This slot, corresponding to flutes of a tap provides two balanced cutting edges and a chip reservoir. See photo of actual chips.

At last . . . a practical, production-proved hardened screw that actually *taps* its own perfect mating threads in any material! Open slot chip reservoir allows fine or curled metal chips and tough, gummy non-metallic cuttings to free themselves readily to prevent binding. Chips are pushed ahead of screw in same manner as in action of spiral pointed tap. Length of thread that can be tapped by this remarkable screw is many times greater than its own diameter. Send for folder and samples.

CONTINENTAL SCREW COMPANY
New Bedford, Massachusetts, U.S.A

BUSINESS AND SALES BRIEFS

EXPANSION of its porcelain and plastics molding plant at Peru, Ind., has been announced by Square D. Co. This expansion has resulted from the increased demand for electrical control and distribution products of the company and the need for a steady source of supply for plastics parts.

◆

Charles E. Klaus, 1233 N. W. Twelfth Ave., Portland, Oreg., has been named Allen-Bradley representative for the Portland area. He has taken over the territory formerly served by Garland-Affolter Enginering Corp.

◆

After four years in the armed forces, Walter C. Burns has returned to United States Rubber Co. and will serve as district sales manager of the mechanical goods division in San Francisco. He will have supervision over mechanical goods sales in northern California and most of Nevada, including the cities of San Francisco, Sacramento, Stockton, Fresno and Reno.

◆

Change of name to Mechanical Products Corp. has been announced by Oliver Maisch & Co., 168 North Ogden Ave., Chicago. Business will be conducted as usual but with enlarged facilities for engineering and manufacturing services. Recently Carl Harris joined the executive staff as vice president and works manager.

◆

With headquarters in the Chicago sales office at 64 East Jackson Blvd., Howard S. Bowen has been appointed sales engineer in the Chicago district for Aluminum Industries Inc., Cincinnati, O.

◆

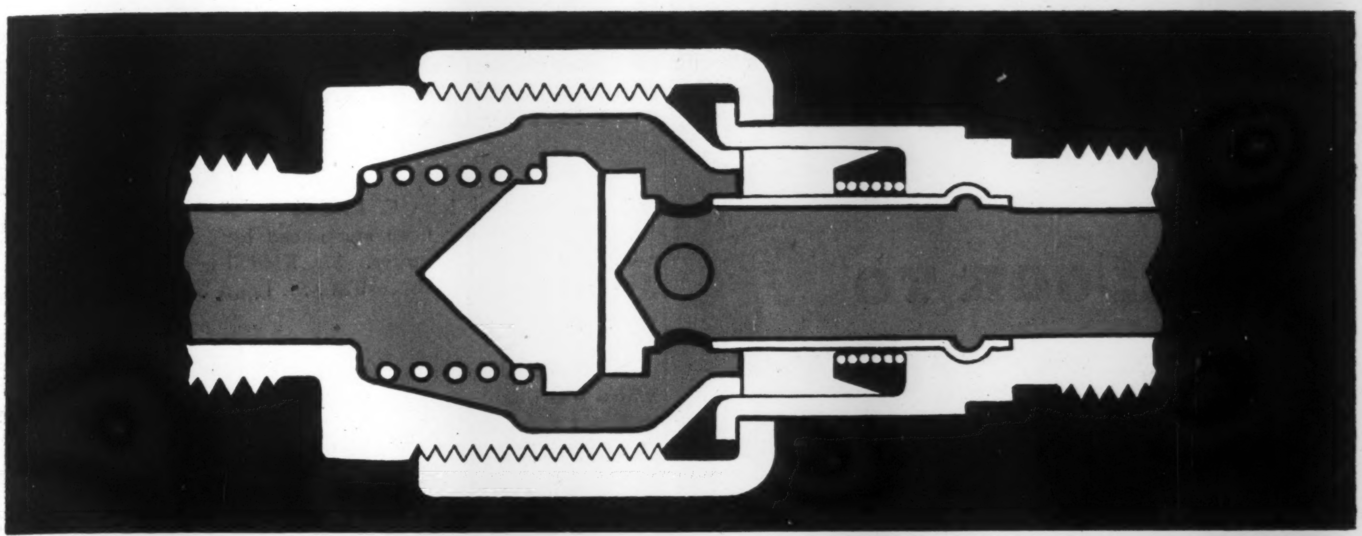
Announced simultaneously by The Dow Chemical Co. are the consolidation of magnesium operations under a separate executive board and general manager, and the immediate resumption of magnesium production at the sea water plant in Freeport, Texas. This brings the company's magnesium sales, fabrication and technical divisions together under the general managership of Dr. J. D. Hanawalt, former director of metallurgical research.

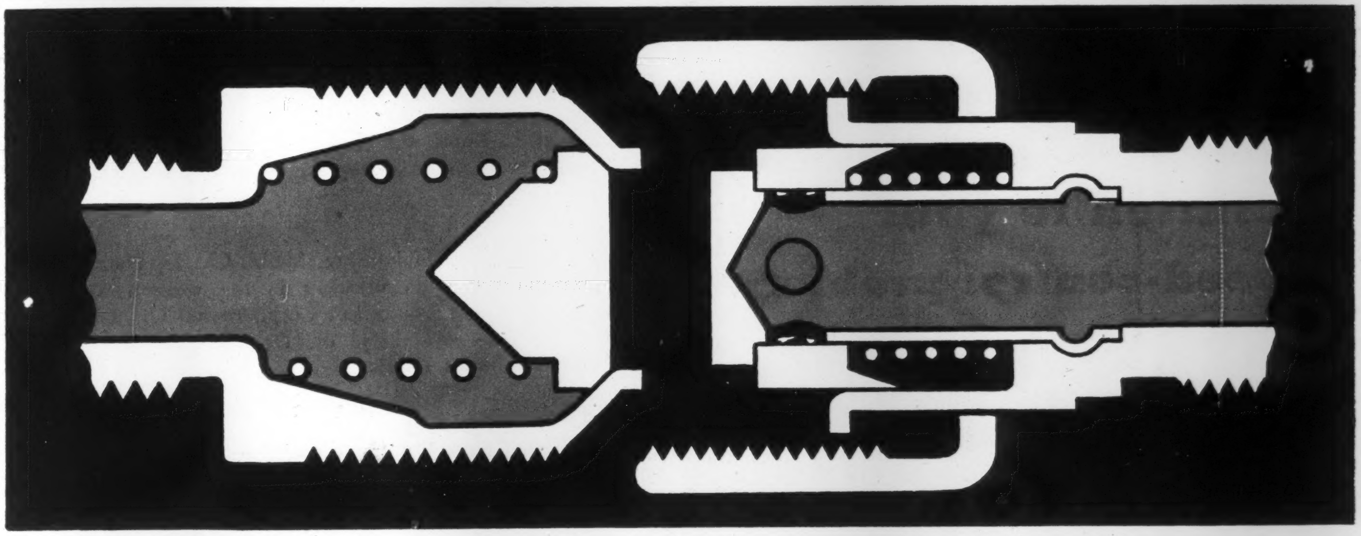
◆

Glenn O. Carson has been appointed by Gotham Instrument Co. Inc. to serve as regional sales manager for the West. He will make his headquarters at 331 Kinnear Place, Seattle 99, and will have the facilities of the Gotham branch factory at 591 Mission St., San Francisco 5.

◆

Recent changes in personnel have been made by Globe Steel Tubes Co., Milwaukee. Gilbert H. Krohn, previously assistant district sales manager in Chicago, has been appointed manager of sales of the Detroit district office. He succeeds Arthur A. Loeffler who has retired after more than twenty-five years of service. Willard C. Christianson, formerly assistant





AEROQUIP Self-Sealing Couplings*

eliminates the use of 2 Valves

With the Aeroquip Self-Sealing Couplings, fluid carrying lines may be instantly disconnected without leakage. Upon separation each half of the coupling automatically closes the line or tube to which it is connected and positively retains the fluid carried therein. No leakage or loss of fluid occurs and no air is allowed to enter the system on reconnection. Suitable for hydraulic and refrigeration systems as well as any lines carrying oils, fuels, coolants, or refrigeration gases.

AEROQUIP FIRSTS

Detachable Hose Fittings
Hydrofuse
X-Washers
*** Another Aeroquip First**

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LOOK TO
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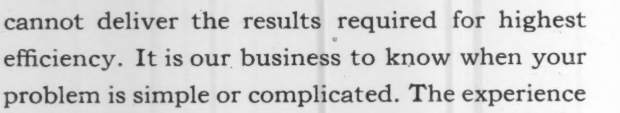
Expect a time-proved solution to your speed-control problem

★ Often, the simple installation of a Lewellen Variable-Speed Transmission or Motor Pulley performs production miracles. Many times, however, even a Lewellen "packaged installation" cannot deliver the results required for highest efficiency. It is our business to know when your problem is simple or complicated. The experience of this organization — pioneers in speed-control — is available to you.

Lewellen Variable-Speed Transmissions, Variable-Speed Motor Pulleys and Automatic Controls serve industry everywhere. Lewellen engineers are constantly finding new ways to adapt modern speed-control to fixed-speed machines and to improve inefficient speed-control methods. Tell us your problem! Look to Lewellen! Lewellen Manufacturing Company, Columbus, Indiana.

LEWELLEN *Variable-Speed*
TRANSMISSIONS—MOTOR PULLEYS



to the vice president in charge of sales at the general sales office in Milwaukee, has been transferred to the Chicago district office as sales agent to succeed Mr. Krohn. Frederick K. Krell has been named sales service supervisor to succeed Mr. Christianson at Milwaukee.

◆

Appointment of John E. Kindall as sales representative for eastern Missouri has been announced by C. P. Clare & Co., Chicago relay manufacturer. Mr. Kindall is proprietor of K-S Electrical Sales, 2004 Locust St., St. Louis 3.

◆

Penn Carbide & Alloy Casting Co. of Canonsburg, Pa., which was established recently, is able now to furnish carbide and cast dies in a wide variety of standard shapes and sizes as well as special designs. Powder metallurgy, precision casting and special casting are the three basic methods of manufacture used.

◆

Addition of four new men to the sales department of the Eaton Reliance Division at Massillon, O., has been announced by Eaton Mfg. Co. These are: Ralph O. Amsden Jr., with headquarters at the Detroit office; John S. Kerr, the Cleveland office; John L. Knott, the New York office; and Clifford A. Esinhart, Western Railroad representative, the Chicago office.

◆

With headquarters in Lansing, Mich., Charles Harrison has been appointed division manager in the western Michigan territory of The Aro Equipment Corp., Bryan, O. Previously Mr. Harrison was assistant in the Detroit and Michigan territory, under Charles Kocsis.

◆

Ampco Metal Inc. has transferred Gordon E. Brown from the main office at Milwaukee to the Hartford, Conn., district office. He will serve as field engineer throughout New England.

◆

Seven new agents have been appointed by the Selenium Rectifier Division of Radio Receptor Co. Inc., New York. These are: Bauman & Bluzat, Chicago; Irvin I. Aaron & Associates, Milwaukee and Minneapolis; M. M. Massey & Associates, Washington; A. Sidney Hardy & Associates, Atlanta; Delta Electronic Equipment Co., New Orleans; Western Agencies Co., Los Angeles; and Arthur T. Hatton & Co., Hartford, Conn., and Boston.

◆

Associated with the steel industry since 1925, Arthur G. Buterbaugh has been named sales manager in the Detroit district of Washington Steel Corp., Washington, Pa. The company, which was organized recently, will produce precision cold-rolled stainless sheet and strip.

◆

Charles G. Pfeffer has opened offices at 475 Fifth Ave., New York 17, and will serve as a consultant for gear engineering.

◆

Return of six naval veterans and a former member of the War Production Board to their prewar jobs in the Industrial Division has been announced by The Timken Roller Bearing Co., Canton, O. These are: R. G. Harmon, field engineering, Chicago; D. G. Gibson, field engineering, Cincinnati; S. T. Salvage, assistant district manager, Industrial Division, Cleve-

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Kodak
it takes 3000 pictures in one second!

That's why the Eastman High-Speed Camera can help solve so many engineering problems

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Precision Gears

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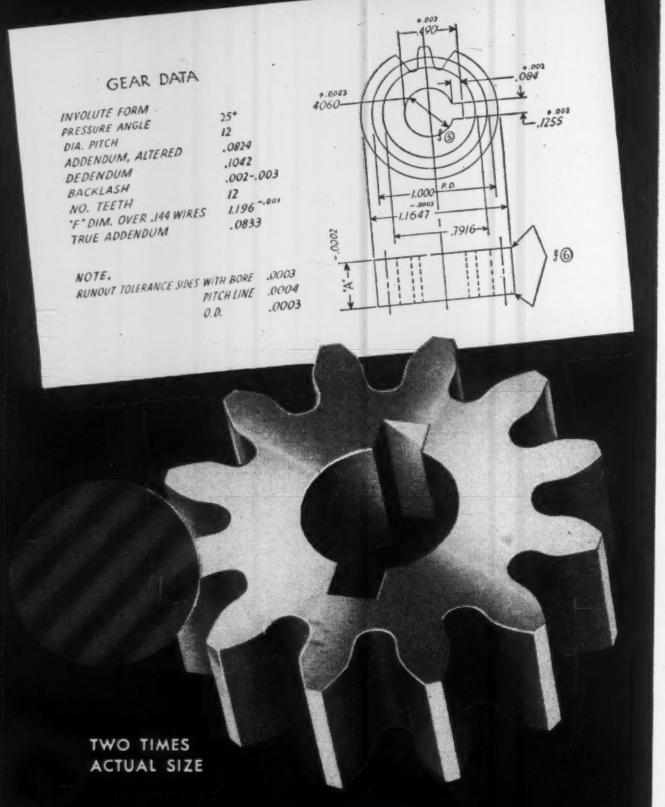

This is one size of the twin spur gears used in McIntyre Series 100 Metering Pumps which deliver ¼ to 3 gpm at pressures up to 1000 psi for oil or up to 200 psi for water at speeds up to 3600 rpm.

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Tolerances like these are standard practice with the McIntyre Co., because our mass production machinery methods are *capable of holding vital dimensions to plus or minus .000025″ . . . surfaces flat to one light band.*

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THE McINTYRE CO.
(FORMERLY ZENITH ASSOCIATES)
PUMPS AND FLUID MOTORS

THE ULTIMATE IN PRECISION ● IDENTIFIED BY THE LIGHT BAND

land; R. L. Williams, field engineer, Cleveland; F. J. Hartshorne, field engineer, Milwaukee; L. M. Meyer, field engineer, Pittsburgh; and L. H. Gegenheimer, district manager, Industrial Division, Boston.

◆

Aluminum Co. of America is planning to construct a large new plant near Davenport, Ia., for the rolling of aluminum sheet and plate. When in operation, the plant will have the capacity to produce more than ten million pounds of sheet and plate per month, and will be able to turn out wider aluminum sheet than any other aluminum rolling mill in the world.

◆

Opening of a Chicago branch office at 608 South Dearborn St. has been announced by National Formetal Co. Inc., Cleveland, pioneer manufacturer of bronze and steel bushings and bearings, and of spacer tubes. T. L. Lanza has been made manager of the new office which will handle sales and service for the northern half of Illinois and the entire state of Wisconsin.

◆

An addition to its plastics plant at Belvidere, N. J., is being constructed by Celanese Corp. of America. It is planned to produce both cellulose acetate and cellulose proprionate molding material in the new unit.

◆

Appointment of J. A. Gulick as sales representative for Oklahoma, Arkansas and Northwestern Texas has been announced by Titan Metal Mfg. Co. of Bellefonte, Pa. Mr. Gulick will have offices at 310 Thompson Bldg., Tulsa, Okla. Also announced by the company is the appointment of L. E. Vail as sales representative for northern Ohio, with offices at 408 Carnegie Hall Bldg., Cleveland.

◆

Construction of a new modern streamlined factory is underway by Duro Test Corp. of North Bergen, N. J., manufacturer of fluorescent and incandescent lamps and electrical products. The new structure will be located directly in the rear of the present plant on Hudson Blvd., and will add 68,000 square feet of space to the present facilities.

◆

American Brake Shoe Co. has appointed J. F. Weller to the newly created post of sales assistant to the president. He will represent the entire company by promoting sales for all divisions of the organization.

◆

According to a recent announcement, Accurate Molding Corp. has removed its factory and office to new and larger quarters at 35-20 48th Ave., Long Island City 1, N. Y.

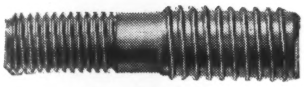
◆

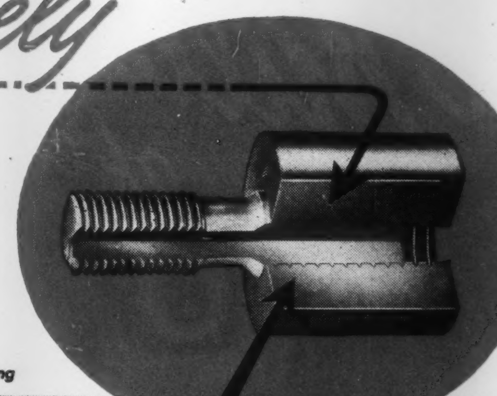
Previously president of Victor Adding Machine Co., Robert Buehler has formed a new engineering research and development firm known as Buehler & Co. which will offer a complete product development service to individuals, manufacturing concerns and management groups. The new company has taken over the extensive facilities of the Victor Research Laboratory at 1607 Howard St., Chicago.

◆

An eleven acre site has been purchased by Ajax Flexible Coupling Co. Inc. of Westfield, N. Y. Plans have been made for immediate erection of a new factory for increasing pro-

THIS STUD *locks securely*

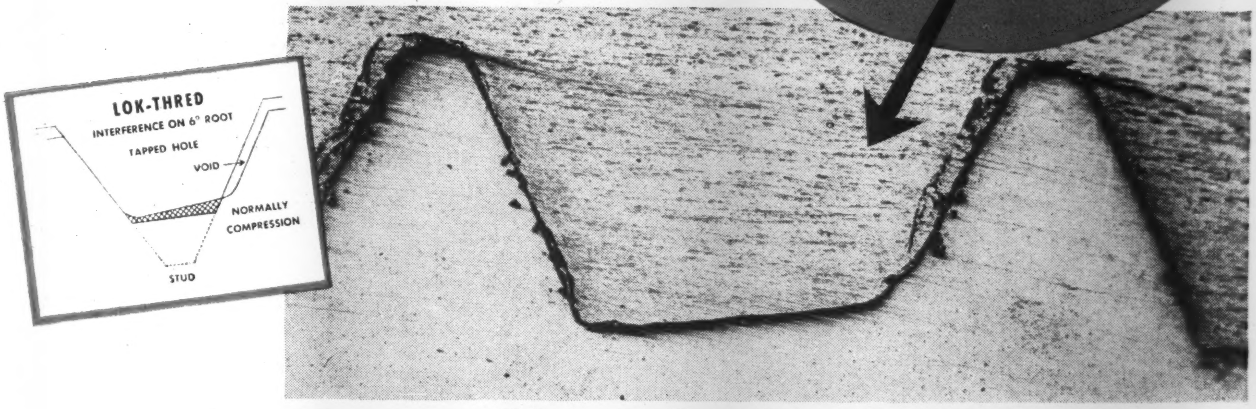




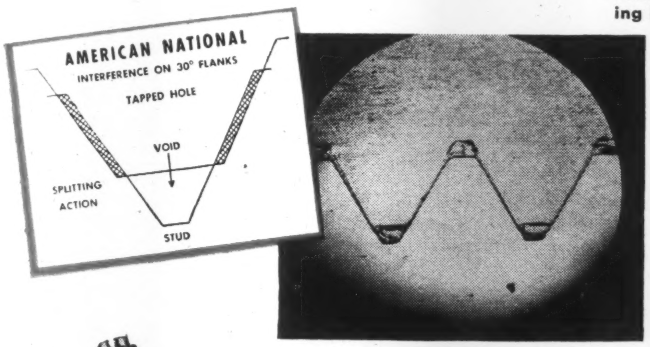
IT'S THE NEW LOK-THRED

MADE BY "NATIONAL"

Patent Pending



Photomicrograph of thread section in place in aluminum, showing how 6° root angle in Lok-Thred design absorbs the load.



Photomicrograph of conventional stud thread (oversize fit in an attempt to lock).

Here's an entirely new principle of thread design—the LOK-THRED!

In conventional threads, stresses result in shearing or stripping action borne by the thread flanks.

The LOK-THRED design puts the load on the 6° angle at the root of the thread so that stresses are carried by compression transmitted to the surrounding metal.

The LOK-THRED is especially suited to studs for use in aluminum and magnesium as well as cast iron or steel. It solves the designer's age-old headache of studs loosening under vibration or lateral motion.

FACTS ABOUT LOK-THRED

1. A modified American National thread designed to lock securely and become tighter in service.
2. Handled with standard tools.
3. Does not require selective fits.
4. Seals positively and in many cases obviates need for blind tapping and adding bosses.
5. Has much higher fatigue limit than ordinary threads.
6. Does not gall when being driven.
7. Does not fret from lateral motion.
8. Entire normal working load carried on 6° angle at root of thread.
9. Stronger in both tension and torsion than ordinary American National threads.
10. Re-usable and on any re-application one additional quarter turn brings the torque back to its original installation value.

Write for samples and full information

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duction of Ajax vibrating conveyors and screens. The plant now occupied by the Ajax Screen & Conveyor Division will be used for development and testing work, and machine shop operations will be continued at the present factory which has been devoted to the production of Ajax-Shaler shakers.

◆

Appointment of I. C. Ebeling as Detroit manager has been announced by Geary Stainless Steel Co., Baltimore. Handling sales of stainless products in all forms, Mr. Ebeling will make his headquarters at 906 Fisher Bldg., Detroit 2. Formerly he was associated with the Ford Motor Co. and G. S. Cochrane.

◆

Plans have been made by Pittsburgh Corning Corp. to build two plants at Sedalia, Mo., for the production of glass block and Foamglas, a cellular glass insulating material. Estimated cost of the expansion program is $2,000,000.

Meetings and Expositions

Aug. 22-24—

Society of Automotive Engineers Inc. National West Coast transportation and maintenance meeting to be held at New Washington Hotel, Seattle. John A. C. Warner, 29 West 39th St., New York 18, is secretary and general manager.

Sept. 11-12—

Society of Automotive Engineers Inc. National tractor meeting to be held at Hotel Schroeder, Milwaukee. John A. C. Warner, 29 West 39th St., New York 18, is secretary and general manager.

Sept. 16-20—

Instrument Society of America. First national instrument conference and exhibit to be held at William Penn Hotel, Pittsburgh. Richard Rimbach, 1117 Wolfendale St., Pittsburgh 12, is executive secretary.

Sept. 30-Oct. 2—

American Society of Mechanical Engineers. Fall meeting to be held at Boston. Additional information may be obtained from headquarters of the society at 29 West 39th St., New York. C. E. Davies is secretary.

Oct. 3-5—

National Electronics Conference Inc. National forum on electronic research, development and application, and exhibits of electronic equipment to be held at Edgewater Beach Hotel, Chicago 14. E. H. Schulz, Illinois Institute of Technology, Technology Center, Chicago 16, is secretary.

Oct. 3-5—

Society of Automotive Engineers Inc. National aeronautical meeting and aircraft engineering display to be held at Biltmore Hotel, Los Angeles. John A. C. Warner, 29 West 39th St., New York 18, is secretary and general manager.

Oct. 9-11—

Porcelain Enamel Institute. Eighth annual forum to be held at University of Illinois. Additional information may be obtained from headquarters of the society at 1010 Vermont Ave., N. W., Washington 5.

Oct. 16-17—

Society of Automotive Engineers Inc. National transportation and maintenance meeting to be held at Hotel Knickerbocker, Chicago. John A. C. Warner, 29 West 39th St., New York 18, is secretary and general manager.

Oct. 23-25—

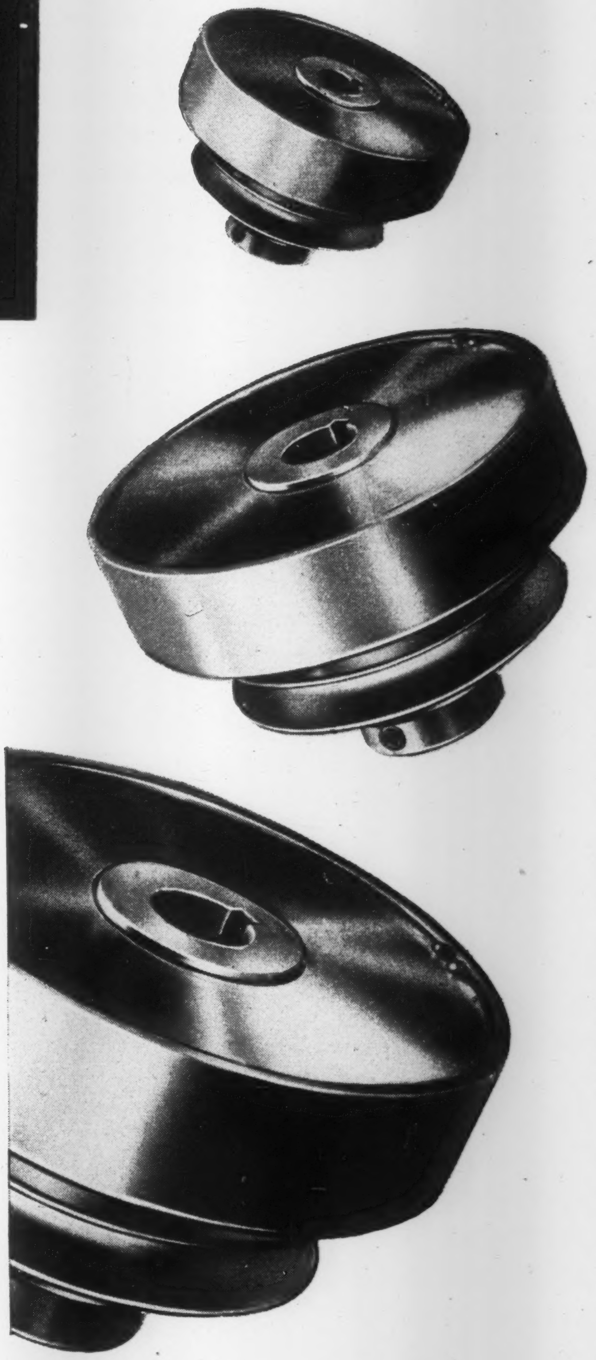
American Society of Body Engineers Inc. Technical convention to be held at Rackham Memorial Bldg., Detroit. Otto Graebner, Murray Corp., Detroit, is secretary.

Oct. 28-30—

American Gear Manufacturers Association. Semiannual meeting to be held at Edgewater Beach Hotel, Chicago 14. Newbold C. Goin, Empire Bldg., Pittsburgh 22, is executive secretary.

Mercury Clutches

Mercury Clutches are available for use with 1/4 h.p. to 15 h.p. electric motors and internal combustion engines.



From Blowers to Washing Machines

The list of prominent users of Mercury Clutches continues to grow and now includes many of the leaders in the electrical industry.

Wherever electrically-powered equipment is used there is usually a place for a Mercury Clutch to make motor starting problems easier . . . to limit starting current . . . to prevent over-loading of the motor . . . to avoid burned-out motor windings, blown fuses, and fire hazards.

The operation of a Mercury Clutch is simple and automatic. Each clutch incorporates a "time-delay" factor which retards the engagement of the clutch long enough to allow the motor to come up to full speed before any load is applied. The result is expressed in terms of much lower starting current . . . a lower connected load . . . and a better power factor.

If your engineering department does not have full information on Mercury Clutches ask us to send you a file of our engineering bulletins.

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